

# vertica-m1-python1.0 Documentation

Flexible as Python, Fast and Scalable as Vertica

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## Executive Summary

This documentation explains the `vertica-ml-python` API by detailing all the functions and by providing significant examples to each one. It allows the user to use his Vertica Database with Python without loading the data in his personal machine first. All the functions execute requests directly in the database in order to gain in efficiency. It combines Vertica aggregations and Python flexibility to create objects similar to the ones available in `pandas` and `sklearn` with the power of a columnar oriented analytic database: Vertica.

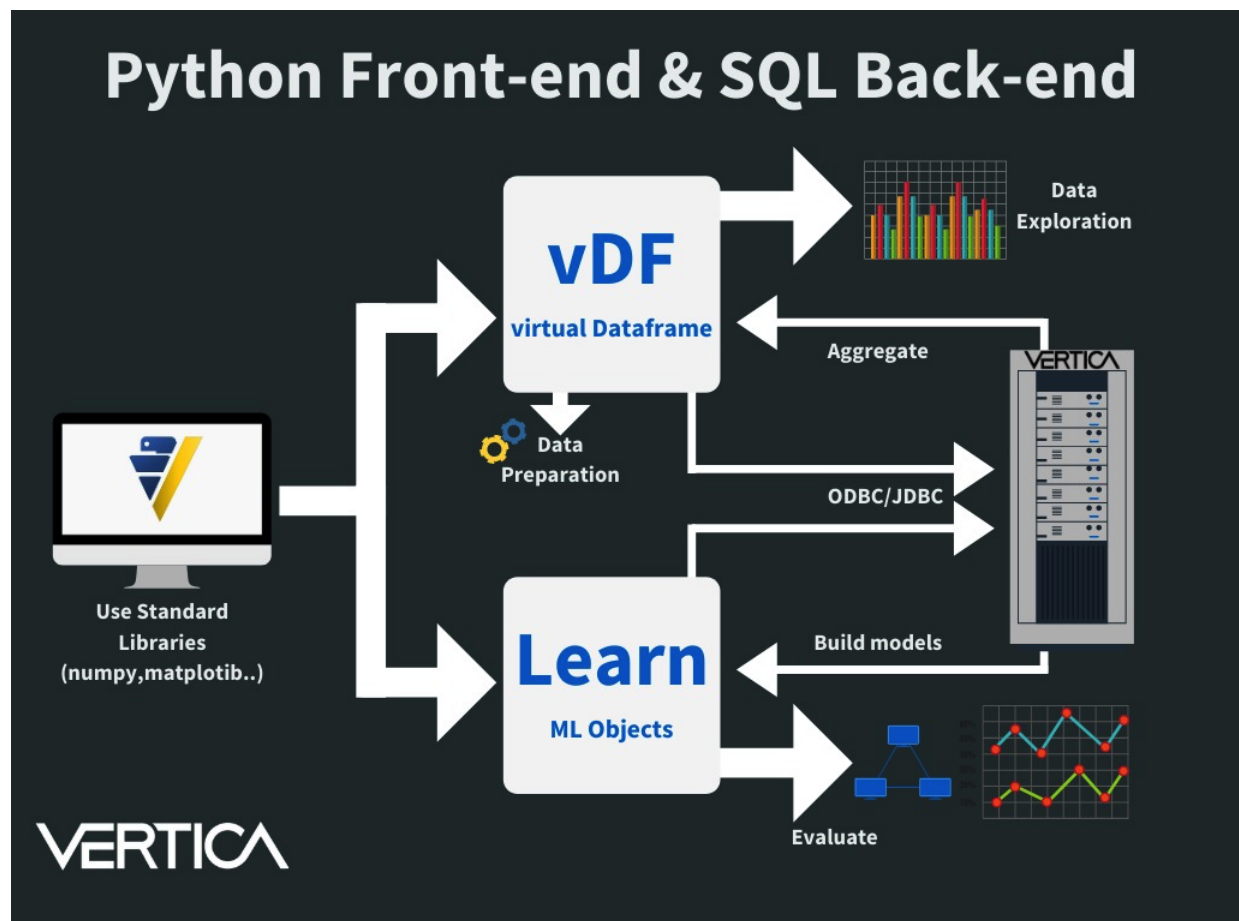
`vertica-ml-python` allows users to use the `vDataframe` (Virtual Dataframe). This object keeps in memory all the users modifications in order to use optimised SQL queries to compute all the necessary aggregations. Thanks to this object, the initial relation is intact and will never be modified. The purpose is to explore, preprocess and clean the object without changing the initial relation.

### What contains `vertica-ml-python`?

This API contains many functions for:

- Data Exploration, Preprocessing and Cleaning: `vertica_ml_python.vdataframe`
- Machine Learning (Regression, Classification, Clustering): `vertica_ml_python.learn`

`vertica-ml-python` helps to explore, preprocess and clean the data without changing the initial relation. It uses scalable Machine Learning Algorithms such as Logistic Regression, Random Forest, SVM and much more... It allows also to evaluate and to optimise models (Classification/Regression Reports, ROC/PRC curves, Parameters tuning...).



## Contents

<b>1 About</b>	<b>11</b>
<b>2 Features</b>	<b>12</b>
<b>3 License</b>	<b>13</b>
<b>4 Quick Start</b>	<b>13</b>
<b>5 Prerequisites</b>	<b>16</b>
5.1 Python Version . . . . .	16
5.2 Standard Libraries . . . . .	16
5.3 Installation . . . . .	16
5.4 Connection to the Database . . . . .	17
5.4.1 ODBC . . . . .	17
5.4.2 JDBC . . . . .	18
<b>6 Jupyter</b>	<b>18</b>
<b>7 Comparison between vertica-ml-python and pandas + scikit</b>	<b>19</b>
7.1 Limitations . . . . .	19
7.1.1 vertica-ml-python . . . . .	19
7.1.2 pandas + scikit . . . . .	19
7.2 Time to load the data . . . . .	19
7.2.1 vertica-ml-python . . . . .	19
7.2.2 pandas + scikit . . . . .	20
7.3 Object Size . . . . .	20
7.3.1 vertica-ml-python . . . . .	20
7.3.2 pandas . . . . .	20
7.4 Time to execute some queries . . . . .	21
7.4.1 vertica-ml-python . . . . .	21
7.4.2 pandas . . . . .	22
7.5 Conclusion . . . . .	24
<b>8 vertica_ml_python.vdataframe</b>	<b>24</b>
8.1 Functions . . . . .	24
8.1.1 read_csv . . . . .	24
8.1.2 read_vdf . . . . .	26
8.1.3 vdf_from_relation . . . . .	27
8.2 Virtual Dataframe . . . . .	28

8.2.1	why Virtual Dataframe ?	29
8.2.2	initialization	30
8.2.3	attributes	30
8.2.4	methods	31
8.2.4.1	abs	31
8.2.4.2	aggregate / agg	32
8.2.4.3	all	32
8.2.4.4	any	33
8.2.4.5	append	34
8.2.4.6	apply	35
8.2.4.7	applymap	36
8.2.4.8	asfreq	36
8.2.4.9	astype	38
8.2.4.10	at_time	38
8.2.4.11	avg / mean	39
8.2.4.12	bar	40
8.2.4.13	beta	42
8.2.4.14	between_time	43
8.2.4.15	boxplot	44
8.2.4.16	catcol	45
8.2.4.17	copy	45
8.2.4.18	corr	46
8.2.4.19	cov	47
8.2.4.20	count	48
8.2.4.21	cummax	49
8.2.4.22	cummin	50
8.2.4.23	cumprod	51
8.2.4.24	cumsum	52
8.2.4.25	current_relation	53
8.2.4.26	datecol	53
8.2.4.27	describe	54
8.2.4.28	drop	56
8.2.4.29	drop_duplicates	57
8.2.4.30	dropna	57
8.2.4.31	dsn_restart	58
8.2.4.32	dtypes	58
8.2.4.33	duplicated	59
8.2.4.34	empty	60

8.2.4.35 eval . . . . .	60
8.2.4.36 expected_store_usage . . . . .	61
8.2.4.37 fillna . . . . .	62
8.2.4.38 filter . . . . .	63
8.2.4.39 first . . . . .	64
8.2.4.40 get_columns . . . . .	65
8.2.4.41 groupby . . . . .	65
8.2.4.42 head . . . . .	66
8.2.4.43 help . . . . .	67
8.2.4.44 hexbin . . . . .	68
8.2.4.45 hist . . . . .	69
8.2.4.46 info . . . . .	71
8.2.4.47 isin . . . . .	71
8.2.4.48 join . . . . .	72
8.2.4.49 kurtosis / kurt . . . . .	73
8.2.4.50 last . . . . .	74
8.2.4.51 load . . . . .	75
8.2.4.52 mad . . . . .	76
8.2.4.53 max . . . . .	77
8.2.4.54 median . . . . .	78
8.2.4.55 memory_usage . . . . .	78
8.2.4.56 min . . . . .	79
8.2.4.57 nlargest . . . . .	80
8.2.4.58 normalize . . . . .	81
8.2.4.59 nsmallest . . . . .	81
8.2.4.60 numcol . . . . .	82
8.2.4.61 pivot_table . . . . .	83
8.2.4.62 plot . . . . .	84
8.2.4.63 product / prod . . . . .	86
8.2.4.64 quantile . . . . .	87
8.2.4.65 rank . . . . .	88
8.2.4.66 rolling . . . . .	88
8.2.4.67 sample . . . . .	90
8.2.4.68 save . . . . .	91
8.2.4.69 scatter . . . . .	92
8.2.4.70 scatter_matrix . . . . .	94
8.2.4.71 select . . . . .	95
8.2.4.72 sem . . . . .	96

8.2.4.73	sessionize . . . . .	96
8.2.4.74	set_cursor . . . . .	98
8.2.4.75	set_dsn . . . . .	98
8.2.4.76	shape . . . . .	98
8.2.4.77	skewness / skew . . . . .	99
8.2.4.78	sort . . . . .	99
8.2.4.79	sql_on_off . . . . .	100
8.2.4.80	statistics . . . . .	101
8.2.4.81	std . . . . .	102
8.2.4.82	sum . . . . .	102
8.2.4.83	tail . . . . .	103
8.2.4.84	time_on_off . . . . .	104
8.2.4.85	to_csv . . . . .	104
8.2.4.86	to_db . . . . .	106
8.2.4.87	to_pandas . . . . .	106
8.2.4.88	to_vdf . . . . .	107
8.2.4.89	var . . . . .	107
8.2.4.90	version . . . . .	108
8.3	Virtual Column . . . . .	108
8.3.1	attributes . . . . .	108
8.3.2	methods . . . . .	109
8.3.2.1	abs . . . . .	109
8.3.2.2	add . . . . .	109
8.3.2.3	add_copy . . . . .	110
8.3.2.4	add_prefix . . . . .	111
8.3.2.5	add_suffix . . . . .	112
8.3.2.6	aggregate / agg . . . . .	113
8.3.2.7	apply . . . . .	114
8.3.2.8	astype . . . . .	115
8.3.2.9	avg / mean . . . . .	115
8.3.2.10	bar . . . . .	116
8.3.2.11	boxplot . . . . .	117
8.3.2.12	category . . . . .	119
8.3.2.13	clip . . . . .	119
8.3.2.14	count . . . . .	120
8.3.2.15	date_part . . . . .	120
8.3.2.16	decode . . . . .	121
8.3.2.17	density . . . . .	122

8.3.2.18 describe . . . . .	123
8.3.2.19 distinct . . . . .	124
8.3.2.20 divide / div . . . . .	125
8.3.2.21 donut . . . . .	126
8.3.2.22 drop . . . . .	127
8.3.2.23 dropna . . . . .	128
8.3.2.24 drop_outliers . . . . .	128
8.3.2.25 dtype . . . . .	129
8.3.2.26 ema . . . . .	130
8.3.2.27 equals / eq . . . . .	131
8.3.2.28 fillna . . . . .	132
8.3.2.29 fill_outliers . . . . .	133
8.3.2.30 ge . . . . .	134
8.3.2.31 get_dummies . . . . .	135
8.3.2.32 gt . . . . .	136
8.3.2.33 head . . . . .	137
8.3.2.34 hist . . . . .	138
8.3.2.35 isdate . . . . .	139
8.3.2.36 isin . . . . .	139
8.3.2.37 isnum . . . . .	140
8.3.2.38 kurtosis / kurt . . . . .	140
8.3.2.39 label_encode . . . . .	141
8.3.2.40 le . . . . .	142
8.3.2.41 lt . . . . .	142
8.3.2.42 mad . . . . .	143
8.3.2.43 max . . . . .	144
8.3.2.44 mean_encode . . . . .	144
8.3.2.45 median . . . . .	145
8.3.2.46 min . . . . .	145
8.3.2.47 mod . . . . .	146
8.3.2.48 mode . . . . .	147
8.3.2.49 mul . . . . .	147
8.3.2.50 neq . . . . .	148
8.3.2.51 next . . . . .	149
8.3.2.52 normalize . . . . .	150
8.3.2.53 numh . . . . .	150
8.3.2.54 nunique . . . . .	151
8.3.2.55 pct_change . . . . .	151

8.3.2.56	pie	152
8.3.2.57	plot	153
8.3.2.58	pow	156
8.3.2.59	prev	157
8.3.2.60	product / prod	158
8.3.2.61	quantile	158
8.3.2.62	rename	159
8.3.2.63	round	159
8.3.2.64	sem	160
8.3.2.65	skewness / skew	161
8.3.2.66	slice	161
8.3.2.67	std	162
8.3.2.68	str_contains	163
8.3.2.69	str_count	164
8.3.2.70	str_extract	164
8.3.2.71	str_replace	165
8.3.2.72	str_slice	166
8.3.2.73	sub	167
8.3.2.74	sum	168
8.3.2.75	tail	169
8.3.2.76	to_enum	169
8.3.2.77	topk	170
8.3.2.78	to_timestamp	171
8.3.2.79	value_counts	172
8.3.2.80	var	172
<b>9</b>	<b>vertica_ml_python.utilities</b>	<b>173</b>
9.1	Functions	173
9.1.1	drop_model	173
9.1.2	drop_table	173
9.1.3	drop_text_index	173
9.1.4	drop_view	174
9.1.5	load_model	174
9.1.6	pandas_to_vertica	174
9.1.7	to_tablesample	175
9.1.8	vertica_cursor	175
9.2	tablesample	176
9.2.1	initialization	176
9.2.2	attributes	176
9.2.3	methods	176



<b>10 vertica_ml_python.learn</b>	<b>176</b>
10.1 vertica_ml_python.learn.cluster	177
10.1.1 DBSCAN	177
10.1.2 KMeans	179
10.2 vertica_ml_python.learn.datasets	181
10.2.1 load_iris	181
10.2.2 load_smart_meters	181
10.2.3 load_titanic	181
10.2.4 load_winequality	182
10.3 vertica_ml_python.learn.decomposition	182
10.3.1 PCA	182
10.3.2 SVD	184
10.4 vertica_ml_python.learn.ensemble	185
10.4.1 RandomForestClassifier	185
10.4.2 RandomForestRegressor	189
10.5 vertica_ml_python.learn.linear_model	192
10.5.1 LinearRegression	192
10.5.2 ElasticNet	192
10.5.3 Lasso	195
10.5.4 LogisticRegression	195
10.5.5 Ridge	199
10.6 vertica_ml_python.learn.metrics	199
10.6.1 Regression	199
10.6.1.1 explained_variance	199
10.6.1.2 max_error	199
10.6.1.3 median_absolute_error	199
10.6.1.4 mean_absolute_error	200
10.6.1.5 mean_squared_error	200
10.6.1.6 mean_squared_log_error	200
10.6.1.7 regression_report	200
10.6.1.8 r2_score	201
10.6.2 Classification	201
10.6.2.1 accuracy_score	201
10.6.2.2 auc	201
10.6.2.3 classification_report	201
10.6.2.4 confusion_matrix	202
10.6.2.5 critical_success_index	202
10.6.2.6 f1_score	202

10.6.2.7	informedness	202
10.6.2.8	log_loss	203
10.6.2.9	markedness	203
10.6.2.10	matthews_corrcoef	203
10.6.2.11	multilabel_confusion_matrix	203
10.6.2.12	negative_predictive_score	204
10.6.2.13	prc_auc	204
10.6.2.14	precision_score	204
10.6.2.15	recall_score	204
10.6.2.16	specificity_score	205
10.7	vertica_ml_python.learn.model_selection	205
10.7.1	best_k	205
10.7.2	cross_validate	206
10.7.3	train_test_split	208
10.8	vertica_ml_python.learn.naive_bayes	208
10.8.1	MultinomialNB	208
10.9	vertica_ml_python.learn.neighbors	210
10.9.1	KNeighborsClassifier	210
10.9.2	KNeighborsRegressor	212
10.9.3	NearestCentroid	214
10.9.4	LocalOutlierFactor	216
10.10	vertica_ml_python.learn.plot	218
10.10.1	elbow	218
10.10.2	lift_chart	219
10.10.3	prc_curve	220
10.10.4	roc_curve	220
10.11	vertica_ml_python.learn.preprocessing	221
10.11.1	Balance	221
10.11.2	CountVectorizer	222
10.11.3	Normalizer	223
10.11.4	OneHotEncoder	225
10.12	vertica_ml_python.learn.svm	226
10.12.1	LinearSVC	226
10.12.2	LinearSVR	229
10.13	vertica_ml_python.learn.tree	232
10.13.1	DecisionTreeClassifier	232
10.13.2	DecisionTreeRegressor	232
10.13.3	DummyTreeClassifier	232
10.13.4	DummyTreeRegressor	232





*"Science knows no country, because knowledge belongs to humanity, and is the torch which illuminates the world."*

**Louis Pasteur**

## 1 About

The 'Big Data' (Tb of data) is now one of the main topics in the Data Science World. Data Scientists are now very important for any organisation. Becoming Data-Driven is mandatory to survive. Vertica is the first real analytic columnar Database and is still the fastest in the market. However, SQL is not enough flexible to be very popular for Data Scientists. Python flexibility is priceless and provides to any user a very nice experience. The level of abstraction is so high that it is enough to think about a function to notice that it already exists. Many Data Science APIs were created during the last 15 years and were directly adopted by the Data Science community (examples: pandas and scikit-learn). However, Python is only working in-memory for a single node process. Even if some famous highly distributed programming languages exist to face this challenge, they are still in-memory and most of the time they can not process on all the data. Besides, moving the data can become very expensive. Data Scientists must also find a way to deploy their data preparation and their models. We are far away from easiness and the entire process can become time expensive.

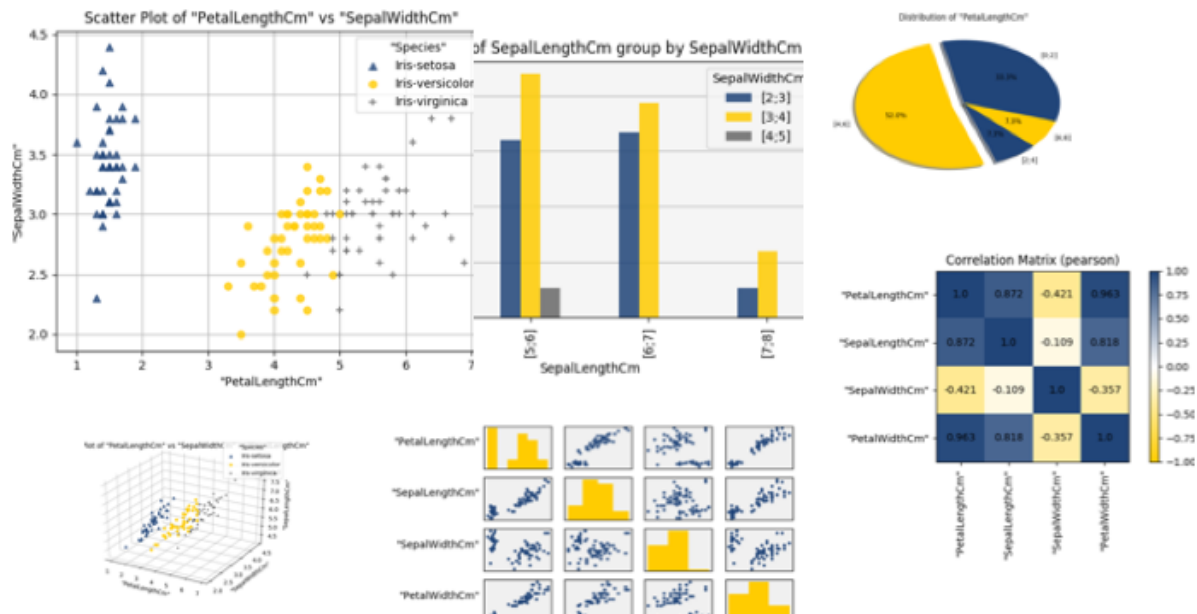
The idea behind VERTICA ML PYTHON is simple: Combining the Scalability of VERTICA with the Flexibility of Python to give to the community what they need \*Bringing the logic to the data and not the opposite\*. This version 1.0 is the work of 3 years of new ideas and improvement. I couldn't have my current skills at the beginning of my journey in the Database World. I needed time and great managers to successfully release this version. I want to thank:

- Yassine Faihe for hiring me as intern to start this project. He is a very pragmatic element who exactly knows in advance if we are following the correct roadmap. Without him, this project would have never seen the light.
- Fouad Teban who is the biggest project supporter. He always trusted the project and provided me many customers to help me on the testing.
- Eugenia Moreno who is a great manager and who knows how to efficiently support my ideas and how to guide me to the correct opportunities.

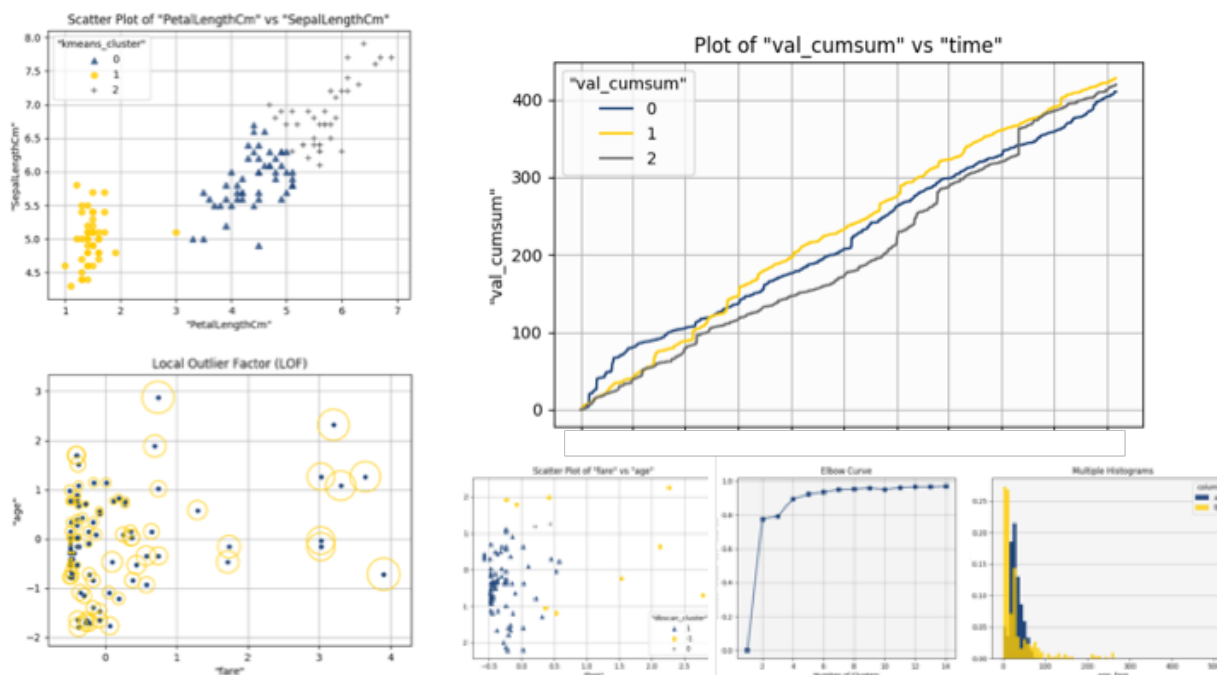
**Badr Ouali - Author of the VERTICA ML PYTHON API**

## 2 Features

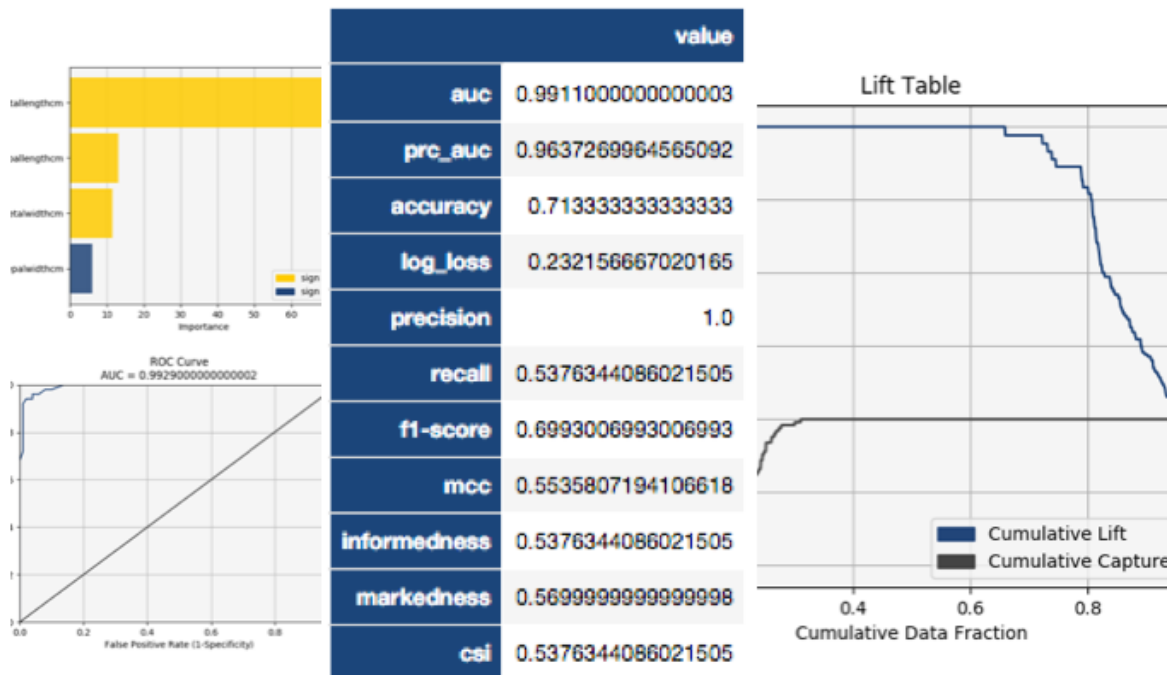
Vertica ML Python is the perfect combination between Vertica and Python. It uses Vertica Scalability and Python Flexibility to help any Data Scientist achieving his goals by bringing the logic to the data and not the opposite. With VERTICA ML PYTHON, start your journey with easy Data Exploration.



Find patterns that you don't know and Detect Anomalies.



Prepare your data easily and build a model with Highly Scalable Vertica ML. Evaluate your model and try to create the most efficient and performant one.



Everything will happen in one place and where it should be: your Database. Without modifying anything but using the speed of Vertica to aggregate the data.

### 3 License

(c) Copyright [2019] Vertica or one of its affiliates. The library is licensed under the Apache License, Version 2.0 (the "License"); You may not use this file except in compliance with the License. You may obtain a copy of the License at: <http://www.apache.org/licenses/LICENSE-2.0> Unless required by applicable law or agreed to in writing, software distributed under the License is distributed on an "AS IS" BASIS, WITHOUT WARRANTIES OR CONDITIONS OF ANY KIND, either express or implied. See the License for the specific language governing permissions and limitations under the License.

### 4 Quick Start

Install the library using the pip command:

```
root@ubuntu:~$ pip3 install vertica-ml-python==1.0
```

Install `vertica_python` or `pyodbc` to build a DB cursor:

```
root@ubuntu:~$ pip3 install vertica_python
```

Create a vertica cursor

```
1 from vertica_ml_python.utilities import vertica_cursor
  cur = vertica_cursor("VerticaDSN")
```

Create the Virtual Dataframe of your relation:

```
1 from vertica_ml_python import vDataframe
2 vdf = vDataframe("my_relation", cursor = cur)
```

If you don't have data to play, you can easily load well known datasets

```
1 from vertica_ml_python.learn.datasets import load_titanic
2 vdf = load_titanic(cursor = cur)
```

You can now play with the data...

```
vdf.describe()
```

```
2
```

```
# Output
```

```
4      min      25%      50%      75%  \
age      0.33     21.0     28.0     39.0  \
6 body      1.0     79.25    160.5    257.5  \
fare      0.0     7.8958    14.4542   31.3875  \
8 parch     0.0      0.0      0.0      0.0  \
pclass     1.0      1.0      3.0      3.0  \
10 sibsp     0.0      0.0      0.0      1.0  \
survived    0.0      0.0      0.0      1.0  \
12      max      unique
age      80.0         96
14 body     328.0        118
fare     512.3292        277
16 parch      9.0         8
pclass       3.0         3
18 sibsp       8.0         7
survived      1.0         2
```

You can also print the SQL code generation using the `sql_on_off` method.

```
1 vdf.sql_on_off()
  vdf.describe()
3
# Output
5 $ Compute the descriptive statistics of all the numerical columns $
7 SELECT SUMMARIZE_NUMCOL("age","body","survived","pclass","parch","fare","sibsp"
  ") OVER ()
FROM
9   (SELECT "age" AS "age",
          "body" AS "body",
```

```

11         "survived" AS "survived",
        "ticket" AS "ticket",
13         "home.dest" AS "home.dest",
        "cabin" AS "cabin",
15         "sex" AS "sex",
        "pclass" AS "pclass",
17         "embarked" AS "embarked",
        "parch" AS "parch",
19         "fare" AS "fare",
        "name" AS "name",
21         "boat" AS "boat",
        "sibsp" AS "sibsp"
23 FROM public.titanic) final_table

```

With Vertica ML Python, it is now possible to solve a ML problem with four lines of code (two if we don't consider the libraries loading).

```

1 from vertica_ml_python.learn.model_selection import cross_validate
  from vertica_ml_python.learn.linear_model import LogisticRegression
3
4 # Data Preparation
5 vdf["sex"].label_encode().parent["boat"].fillna(method = "0ifnull").parent["
    name"].str_extract(' ([A-Za-z]+)\.').parent.eval("family_size", expr = "
    parch + sibsp + 1").drop(columns = ["cabin", "body", "ticket", "home.dest"
    ])[ "fare"].fill_outliers().parent.fillna().to_db("titanic_clean")
7
8 # Model Evaluation
9 cross_validate(RandomForestClassifier("logit_titanic", cur, max_leaf_nodes =
    100, n_estimators = 30), "titanic_clean", ["age", "family_size", "sex", "
    pclass", "fare", "boat"], "survived", cutoff = 0.35)
11
12 # Output
13
14 auc                                prc_auc    \
1-fold    0.9877114427860691    0.9530465915039339    \
15 2-fold    0.9965555014605642    0.7676485351425721    \
    3-fold    0.9927239216549301    0.6419135521132449    \
16 avg            0.992330288634            0.787536226253    \
    std            0.00362128464093            0.12779562393    \
17
18 accuracy                                log_loss    \
1-fold    0.971291866028708    0.0502052541223871    \
19 2-fold    0.983253588516746    0.0298167751798457    \
    3-fold    0.964824120603015    0.0392745694400433    \
20 avg            0.973123191716            0.0397655329141    \
    std            0.0076344236729            0.00833079837099    \
21
22 precision                                recall    \
1-fold            0.96                                0.96    \
23 2-fold    0.9556962025316456                                1.0    \
    3-fold    0.9647887323943662    0.9383561643835616    \
24
25

```



```

27 avg          0.960161644975          0.966118721461    \\
   std          0.00371376912311        0.025535200301    \\
29                                     f1-score          mcc    \\
   1-fold       0.9687259282082884      0.9376119402985075    \\
31 2-fold       0.9867172675521821      0.9646971010878469    \\
   3-fold       0.9588020287309097      0.9240569687684576    \\
33 avg          0.97141507483          0.942122003385    \\
   std          0.0115538960753         0.0168949813163    \\
35                                     informedness      markedness  \\
   1-fold       0.9376119402985075      0.9376119402985075    \\
37 2-fold       0.9737827715355807      0.9556962025316456    \\
   3-fold       0.9185148945422918      0.9296324823943662    \\
39 avg          0.943303202125          0.940980208408    \\
   std          0.0229190954261         0.0109037699717    \\
41                                     csi
   1-fold       0.9230769230769231
43 2-fold       0.9556962025316456
   3-fold       0.9072847682119205
45 avg          0.928685964607
   std          0.0201579224026

```

Happy Playing !

## 5 Prerequisites

### 5.1 Python Version

vertica-ml-python works with at least:

- **Vertica:** 9.1 (with previous versions, some functions and algorithms may not be available)
- **Python:** 3.6

### 5.2 Standard Libraries

vertica-ml-python library is only using the standard Python libraries such as matplotlib, numpy... Other libraries can be used as anytree for tree visualization or sqlparse for SQL indentation but they are optional.

### 5.3 Installation

To install vertica-ml-python, you can use the pip command:

```
root@ubuntu:~$ pip3 install vertica-ml-python==1.0
```

You can also drag and drop the vertica\_ml\_python folder in the site-package folder of the Python framework. In the MAC environment, you can find it in:

```
/Library/Frameworks/Python.framework/Versions/3.6/lib/python3.6/site-packages
```

Another way is to call the library from where it is located.

You can then import each library element using the usual Python syntax.

```
1 # to import the vDataframe
  from vertica_ml_python import vDataframe
3 # to import the Logistic Regression
  from vertica_ml_python.learn.linear_model import LogisticRegression
```

Everything is well detailed in the following documentation.

## 5.4 Connection to the Database

This step is useless if `vertica-python` or `pyodbc` is already installed and you have a DSN in your machine. With this configuration, you do not need to manually create a cursor. It is possible to create a `vDataframe` using directly the DSN (`dsn` parameter of the `vDataframe`).

### 5.4.1 ODBC

To connect to the database, the user can use an ODBC connection to the Vertica database. `vertica-python` and `pyodbc` provide a cursor that will point to the database. It will be used by the `vertica-ml-python` to create all the different objects.

```
#
2 # vertica_python
  #
4 import vertica_python

6 # Connection using all the DSN information
conn_info = {'host': "10.211.55.14", 'port': 5433, 'user': "dbadmin", '
           password': "XxX", 'database': "testdb"}
8 cur = vertica_python.connect(** conn_info).cursor()

10 # Connection using directly the DSN
from vertica_ml_python.utilities import to_vertica_python_format # This
    function will parse the odbc.ini file
12 dsn = "VerticaDSN"
cur = vertica_python.connect(** to_vertica_python_format(dsn)).cursor()

14 #
16 # pyodbc
  #
18 import pyodbc

20 # Connection using all the DSN information
driver = "/Library/Vertica/ODBC/lib/libverticaodbc.dylib"
```

```
22 server = "10.211.55.14"
    database = "testdb"
24 port = "5433"
    uid = "dbadmin"
26 pwd = "XxX"
    dsn = ("DRIVER={}; SERVER={}; DATABASE={}; PORT={}; UID={}; PWD={};").format(
        driver, server, database, port, uid, pwd)
28 cur = pyodbc.connect(dsn).cursor()

30 # Connection using directly the DSN
    dsn = ("DSN=VerticaDSN")
32 cur = pyodbc.connect(dsn).cursor()
```

### 5.4.2 JDBC

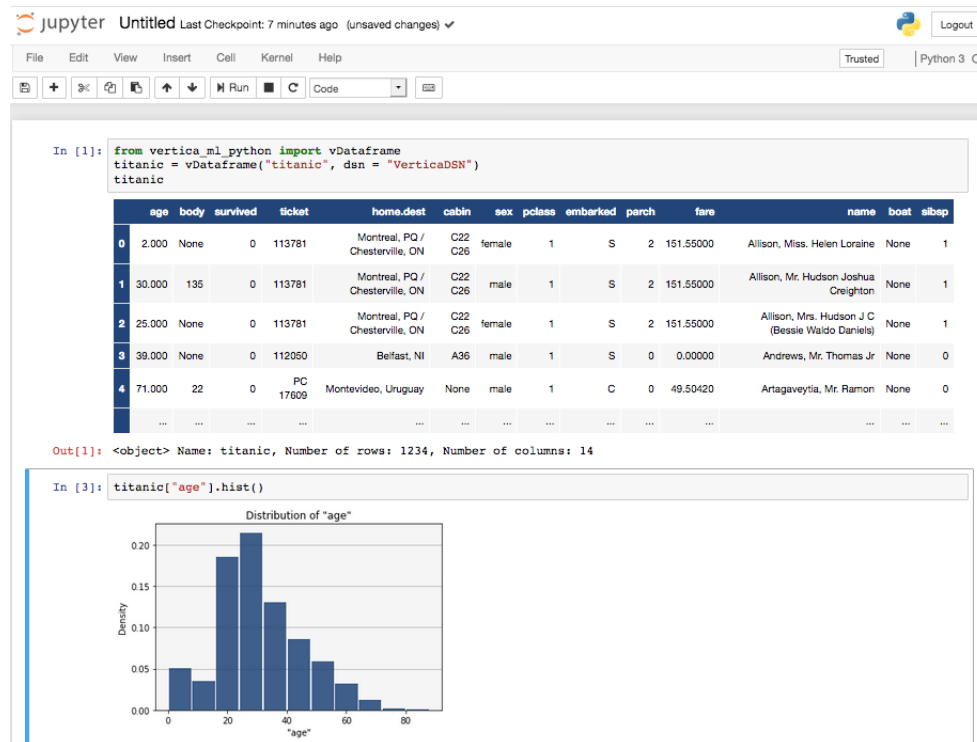
The user can also use a JDBC connection to the Vertica Database.

```
import jaydebeapi

2 uid = "dbadmin"
4 pwd = "XxX"
    driver = "/Library/Vertica/JDBC/vertica-jdbc-9.0.1-0.jar" #Path to JDBC Driver
6 url = 'jdbc:vertica://10.211.55.14:5433/'
    name = 'com.vertica.jdbc.Driver'
8 cur = jaydebeapi.connect(name, [url, uid, pwd], driver).cursor()
```

## 6 Jupyter

Jupyter offers a really beautiful interface to use vertica-ml-python.



Besides a lot of guided notebooks will be available in order to understand the library.

## 7 Comparison between vertica-ml-python and pandas + scikit

All the results of this section are obtained using a single node machine (to have a real comparison) with 128Gb of memory.

### 7.1 Limitations

#### 7.1.1 vertica-ml-python

vertica-ml-python has no limitation as it uses Vertica to compute all the aggregations it needs. If we want to increase the speed, we can increase the number of nodes or do query tuning by building the appropriate projections.

#### 7.1.2 pandas + scikit

pandas and scikit have real limitations. They both need to load data in memory and we can not increase it indefinitely.

### 7.2 Time to load the data

#### 7.2.1 vertica-ml-python

If the data is inside a Vertica database, no operation is needed. In the other cases, we need to transfer the data to Vertica. As we are trying to solve the main 'Big Data' issues, the purpose of this library is to avoid moving the data and to bring the logic to the data (not the opposite). It is highly recommended to already have the data in Vertica (even if the time to create the table is still lower than the one to create the pandas.DataFrame).

## 7.2.2 pandas + scikit

The data must be loaded in memory. It can take a lot of time depending on where the data is. To give a first idea, you can see the following result.

```
# Using 35M of rows (the whole dataset) - Less than 4Gb
2 start_time = time.time()
expedia_df = pandas.read_sql("SELECT * FROM expedia_train", conn)
4 print(time.time() - start_time)

6 # Output
1135.22843092306093

8 # Using 10M of rows - Less than 1Gb
10 start_time = time.time()
expedia_df = pandas.read_sql("SELECT * FROM expedia_train LIMIT 10000000",
    conn)
12 print(time.time() - start_time)

14 # Output
281.51524472236633

16 # Using 1M of rows - Less than 100Mb
18 start_time = time.time()
expedia_df = pandas.read_sql("SELECT * FROM expedia_train LIMIT 1000000", conn)
20 print(time.time() - start_time)

22 # Output
42.53745484352112
```

We can notice the complexity of in-memory processing when reaching Big Data. Besides, the limitation is the power of the single-node machine you are using.

## 7.3 Object Size

### 7.3.1 vertica-ml-python

The size of a `vDataFrame` will never exceed some kilo bytes.

```
1 print(expedia.memory_usage())

3 # Output
5566
```

### 7.3.2 pandas

The size of a `pandas.DataFrame` will be proportional to the dataset volume.

```
print(sys.getsizeof(expedia_df))
```

```
2  
# Output  
4 10846031144
```

More than a GB of memory is used. We can imagine the impact in our personal machine. If the user wants to use `pandas.DataFrame` on very huge dataset, he needs a very powerful machine. Knowing that it is hard to have today a personal machine exceeding 32GB of RAM, the limitation is obvious. These in-memory libraries can only process small datasets (less than 10GB) which is not nowadays 'Big Data' (we can consider the 'Big Data' border as 1TB).

## 7.4 Time to execute some queries

### 7.4.1 vertica-ml-python

Let's start with `vertica-ml-python`:

```
# Using 35M of rows (the whole dataset)  
2 #  
# describe  
4 #  
start_time = time.time()  
6 expedia.describe()  
print(time.time() - start_time)  
8  
# Output  
10 94.45896601676941  
12 #  
# categorical hist  
14 #  
start_time = time.time()  
16 expedia["is_mobile"].hist()  
print(time.time() - start_time)  
18  
# Output  
20 0.480072021484375  
22 # Using 10M of rows  
#  
24 # describe  
#  
26 start_time=time.time()  
expedia.describe()  
28 print(time.time() - start_time)  
30 # Output  
28.198142528533936  
32 #
```

```
34 # categorical hist
35 #
36 start_time = time.time()
37 expedia["is_mobile"].hist()
38 print(time.time() - start_time)
39
40 # Output
41 0.4742517471313477
42
43 # Using 1M of rows
44 #
45 # describe
46 #
47 start_time = time.time()
48 expedia.describe()
49 print(time.time() - start_time)
50
51 # Output
52 2.8560750484466553
53
54 #
55 # categorical hist
56 #
57 start_time = time.time()
58 expedia["is_mobile"].hist()
59 print(time.time() - start_time)
60
61 # Output
62 0.3278229236602783
```

## 7.4.2 pandas

And now pandas:

```
# Using 35M of rows (the whole dataset)
2 #
3 # describe
4 #
5 start_time = time.time()
6 expedia_df.describe()
7 print(time.time() - start_time)
8
9 # Output
10 75.72856092453003
11
12 #
13 # categorical hist
```

```
14 #
    start_time = time.time()
16 expedia_df["is_mobile"].hist()
    print(time.time() - start_time)
18
    # Output
20 3.210484266281128
22
    # Using 10M of rows
    #
24 # describe
    #
26 start_time = time.time()
    expedia_df.describe()
28 print(time.time() - start_time)
30
    # Output
    20.789332389831543
32
    #
34 # categorical hist
    #
36 start_time = time.time()
    expedia_df["is_mobile"].hist()
38 print(time.time() - start_time)
40
    # Output
    0.36867237091064453
42
    # Using 1M of rows
    #
44 # describe
    #
46 #
    start_time = time.time()
48 expedia_df.describe()
    print(time.time() - start_time)
50
    # Output
52 1.2540433406829834
54
    #
    # categorical hist
    #
56 #
    start_time = time.time()
58 expedia_df["is_mobile"].hist()
    print(time.time() - start_time)
60
```



```
# Output
62 0.08945250511169434
```

## 7.5 Conclusion

At the end, we have more or less the same execution time with a little advantage to `pandas` for some functions. However, do not forget that `pandas` is in-memory processing. At the end, `vertica-ml-python` is more robust and offers more possibilities by processing the data directly where they live. Besides some functions to prepare the data will be time consuming using `pandas` whereas it will be very fast for `vertica-ml-python` as only the grammar of the different transformations is kept in memory. If the projections are correctly made, we could reduce drastically the processing time. We can also reduce the processing time by increasing the number of nodes. `vertica-ml-python` uses the Python flexibility and Vertica Scalability to help any Python user to follow the entire Data Science cycle without moving the data.

## 8 `vertica_ml_python.vdataframe`

### 8.1 Functions

The following functions will help the user to build a `vDataFrame` from the `vertica-ml-python` format (`.vdf`) or `csv` files. There is also the possibility to build the `vDataFrame` from more complex relations using the `vdf_from_relation` function.

#### 8.1.1 `read_csv`

```
read_csv(
2     path: str,
      cursor,
4     schema: str = 'public',
      table_name: str = '',
6     delimiter: str = ',',
      header_names: list = [],
8     dtype: dict = {},
      null: str = '',
10    enclosed_by: str = '"',
      escape: str = '\\',
12    skip: int = 1,
      genSQL: bool = False,
14    return_dlist: bool = False,
      parse_n_lines: int = -1)
```

Read a `csv` file and store it in the Vertica Database.

#### Parameters

- **path:** `<str>`  
Path to the `csv` file.

- **cursor:** *<object>*  
Database Cursor.
- **schema:** *<str>*, optional  
Schema used to store the csv file.
- **table\_name:** *<str>*, optional  
Table name used to store the csv file.
- **delimiter:** *<str>*, optional  
Delimiter used to parse the file.
- **header\_names:** *<list>*, optional  
List with the columns name (to use if the csv file has no header).
- **dtype:** *<dict>*, optional  
Dictionary of all the columns types (it is used if header\_names is defined). It makes the loading process faster as the parser has not to identify the types.
- **null:** *<str>*, optional  
How the null elements are encoded.
- **enclosed\_by:** *<str>*, optional  
How the text elements are enclosed.
- **escape:** *<str>*, optional  
How the escape is encoded.
- **skip:** *<positive int>*, optional  
Number of elements to skip.
- **genSQL:** *<bool>*, optional  
Generate the SQL used to create the table.
- **return\_dlist:** *<bool>*, optional  
Return a dictionary of the columns names and their respective types. Do not store the csv file in the Database. This parameter can be useful if we want to be sure that the parser guessed the right types.
- **parse\_n\_lines:** *<int>*, optional  
The parser will only parse a limited number of lines to guess the types. This parameter must be used if the file volume is big.

## Returns

The Virtual Dataframe of the new relation.

## Example

```

1 from vertica_ml_python.vdataframe import read_csv
2 titanic = read_csv('titanic.csv', cur)
3
4 # Output
5      cabin      sex  pclass  embarked  \\
6 0    C22 C26  female        1         S  \\
7 1    C22 C26   male        1         S  \\
8 2    C22 C26  female        1         S  \\

```

```

9 3      A36      male      1      S      \\
10 4      None     male      1      C      \\
11 ...      ...      ...      ...      ...      \\
      parch      fare      name      \\
13 0      2      151.55000      Allison, Miss. Helen Loraine      \\
14 1      2      151.55000      Allison, Mr. Hudson Joshua Creighton      \\
15 2      2      151.55000      Allison, Mrs. Hudson J C (Bessie Wald...      \\
16 3      0      0.00000      Andrews, Mr. Thomas Jr      \\
17 4      0      49.50420      Artagaveytia, Mr. Ramon      \\
      ...      ...      ...      ...      \\
19 Name: titanic, Number of rows: 1234, Number of columns: 14

```

### 8.1.2 read\_vdf

```
1 read_vdf(path: str, cursor)
```

Read a vdf file and load the corresponding vDataFrame.

#### Parameters

- **path:** <str>  
Path to the csv file.
- **cursor:** <object>  
Database Cursor.

#### Returns

The Virtual Dataframe corresponding to the one described in the vdf file.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.to_vdf('titanic')
  from vertica_ml_python.vdataframe import read_vdf
5 titanic = read_vdf('titanic.vdf', cur)

7 # Output
      cabin      sex      pclass      embarked      \\
9 0      C22 C26      female      1      S      \\
10 1      C22 C26      male      1      S      \\
11 2      C22 C26      female      1      S      \\
12 3      A36      male      1      S      \\
13 4      None     male      1      C      \\
      ...      ...      ...      ...      \\
15      parch      fare      name      \\

```

```

0          2      151.55000          Allison, Miss. Helen Loraine  \\
17 1          2      151.55000          Allison, Mr. Hudson Joshua Creighton  \\
2          2      151.55000 Allison, Mrs. Hudson J C (Bessie Wald...  \\
19 3          0      0.00000          Andrews, Mr. Thomas Jr  \\
4          0      49.50420          Artagaveytia, Mr. Ramon  \\
21 ...      ...      ...      ...  \\
Name: titanic, Number of rows: 1234, Number of columns: 14

```

### 8.1.3 vdf\_from\_relation

```

vdf_from_relation(
2     relation: str,
     name: str = "VDF",
4     cursor = None,
     dsn: str = "")

```

Build a vDataFrame using the defined relation.

#### Parameters

- **relation:** <str>  
SQL Relation.
- **name:** <str>, optional  
Name of the new vDataFrame.
- **cursor:** <object>, optional  
Database Cursor.
- **dsn:** <str>, optional  
Database DSN.

#### Returns

The vDataFrame of the input relation.

#### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT 2 AS x, 1 AS y) UNION ALL (SELECT 10 AS x, 4 AS y) UNION
      ALL (SELECT 10 AS x, 5 AS y)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5 # Output
      x      y
7 0      2      1
1 1     10      4
9 2     10      5
Name: VDF, Number of rows: 3, Number of columns: 2

```

## 8.2 Virtual Dataframe

The `vDataframe` is a Python object which will keep in mind all the user modifications in order to use an optimised SQL query. It will send the optimised SQL query to the database which will aggregate and return the final result. `vDataframe` will create for each column of the relation a `vColumn` (Virtual Column) which will store for each column its name and its transformations. Thus, `vDataframe` allows to do easy data preparation and exploration without modifying the data.

`vColumn` and `vDataframe` coexist and one can not live without the other. `vColumn` will use the `vDataframe` information and reciprocally. It is imperative to understand both structures to know how to use the entire object.

When the user imputes or filters the data, the `vDataframe` keeps all the transformations in memory to select for each query the needed data in the main relation. Let's try to understand thanks to an example.

```

# We create the vDataframe
2 titanic = vDataframe('titanic', dsn = 'VerticaDSN')

# We filter some values
4 titanic.filter("fare < 100")

6 84 elements were filtered

# We impute the column age
10 titanic["age"].fillna(method = "mean")

12 232 elements were filled

# We drop some missing values
14 titanic["fare"].dropna()

16 /\ \ Warning: Nothing was dropped

# We encode the column embarked
20 titanic["embarked"].label_encode()

22 # We print all the queries used during the next executions
titanic.sql_on_off()

24

# We summarize our vDataframe
26 titanic.describe()

```

To compute the descriptives statistics, the following query was generated by our `vDataframe`:

```

1 SELECT SUMMARIZE_NUMCOL("age", "body", "passenger class", "embarked", "parch",
   "fare", "sibsp", "survived") OVER ()
FROM
3   (SELECT COALESCE("age", 29.6471459694989) AS "age",
   "body" AS "body",
5   "passenger class" AS "passenger class",
   "ticket" AS "ticket",
7   "cabin" AS "cabin",
   "sex" AS "sex",

```

```

9         "home.dest" AS "home.dest",
10        DECODE("embarked", 'C', 0, 'Q', 1, 'S', 2, 3) AS "embarked",
11        "parch" AS "parch",
12        "fare" AS "fare",
13        "name" AS "name",
14        "boat" AS "boat",
15        "sibsp" AS "sibsp",
16        "survived" AS "survived"
17    FROM
18        (SELECT "age" AS "age",
19             "body" AS "body",
20             "passenger class" AS "passenger class",
21             "ticket" AS "ticket",
22             "cabin" AS "cabin",
23             "sex" AS "sex",
24             "home.dest" AS "home.dest",
25             "embarked" AS "embarked",
26             "parch" AS "parch",
27             "fare" AS "fare",
28             "name" AS "name",
29             "boat" AS "boat",
30             "sibsp" AS "sibsp",
31             "survived" AS "survived"
32         FROM public.titanic) t1
33    WHERE fare < 100) final_table

```

The vDataframe will try to keep in mind where the transformations occurred in order to use the appropriate query. In that case, when the user has done a lot of transformations, it is highly recommended to save the vDataframe in the Database in order to gain in efficiency (using the `to_db` method). We can also see all the modifications using the `info` method.

```

1 titanic.info()
2
3 #Output
4 The vDataframe was modified many times:
5 * {Fri Nov 22 18:06:10 2019} [Filter]: 84 elements were filtered using the
6   filter 'fare < 100'
7 * {Fri Nov 22 18:06:26 2019} [Fillna]: 232 missing values of the vColumn '"
8   age"' were filled.
9 * {Fri Nov 22 18:06:54 2019} [Label Encoding]: Label Encoding was applied to
10  the vColumn '"embarked"' using the following mapping:
11  C => 0   Q => 1   S => 2

```

### 8.2.1 why Virtual Dataframe ?

As the vDataframe keeps in mind all the user actions, it can easily be recreated from scratch. Besides, if the connection to the database failed, it is easy to set a new database cursor using the `set_cursor` method or if the connection

was made using a DSN the `dsn_restart` method. The Virtual Dataframe will never load data in-memory, all the aggregations are computed thanks to Vertica. The user feels like using `pandas` whereas the data is not stored in-memory but exactly where it should be (in the Database!).

## 8.2.2 initialization

```
class vDataframe (
2     input_relation: str, # The relation used to build the vDataframe
    cursor = None, # The DB cursor
4     dsn: str = "", # The DB DSN
    usecols: list = []) # Build the vDataframe using only specific columns
```

To instantiate a new Virtual Dataframe, the user can use a database cursor and the name of a relation (table or view).

```
1 from vertica_ml_python import vDataframe

3 vdf = vDataframe(relation, cur)
```

The simplest way is to use directly a DSN (without setting a cursor).

```
1 vdf = vDataframe(relation, dsn = "VerticaDSN")
```

Using this method, the Virtual Dataframe will keep in mind the DSN name and in case of connection failure, the user can restart a connection using the `dsn_restart` method.

### Example

```
1 titanic = vDataframe("titanic", cursor)

3 #Output
   age      boat      body      cabin      embarked      fare      \
5 0   None      1   None      None      S      26.00000  \
1 1   None     10   None      E101      Q      12.35000  \
7 2   None     10   None      None      S      16.10000  \
3 3   None     11   None      None      S      33.00000  \
9 4   None     13   None      None      Q       7.72080  \
5 5   None     13   None      None      Q       7.73330  \
11 ...      ...      ...      ...      ...      ...      \
--More--
13 Name: titanic, Number of rows: 1234, Number of columns: 14
```

## 8.2.3 attributes

When the Virtual Dataframe is created, it will create as many Virtual Columns as there are columns in the input relation (`columns` attribute). It will keep in mind the cursor, the relation and the DSN if this connection method is used. It will also create 6 other attributes in order to keep in mind the user modifications.

- `order_by`: how to sort the data

- `where`: all the filters.
- `query_on`: print all the queries executed by the `vDataframe` in the terminal.
- `time_on`: print all the queries elapsed time in the terminal.
- `history`: all the user modifications.
- `saving`: all the user saving.

For example, when the user wants to create a new column in the Virtual Dataframe. It will create a new Virtual Column and it will add it in the list of Virtual Columns (`columns` attribute). If the user wants to delete a column, the Virtual Dataframe will simply delete it from the list of Virtual Columns. The initial relation is then never changed !

## 8.2.4 methods

### 8.2.4.1 `abs`

```
1 vDataframe.abs(self, columns: list = [])
```

Apply the Absolute function to the selected columns.

#### Parameters

- **columns**: *<list>*, optional  
List of Columns. If this parameter is empty, the method will be applied to all the numerical columns.

#### Returns

The Virtual Dataframe itself.

#### Example

```
1 from vertica_ml_python.vdataframe import vdf_from_relation
2 relation = "((SELECT 1 AS x, -1 AS y) UNION ALL (SELECT -3 AS x, -4 AS y)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5 #Output
6      x      y
7  0     1    -1
8  1    -3    -4
9 Name: VDF, Number of rows: 2, Number of columns: 2

11 vdf.abs()

13 #Output
14      x      y
15  0     1     1
16  1     3     4
17 Name: VDF, Number of rows: 2, Number of columns: 2
```



### 8.2.4.2 aggregate / agg

```
vDataframe.aggregate(self, func: list, columns: list = [])
```

Aggregate all the different columns.

#### Parameters

- **func:** *<list>*  
List of the different aggregations.
- **columns:** *<list>*, optional  
List of Columns. If this parameter is empty, all the columns will be aggregated.

#### Returns

The `tablesample` type containing the aggregations (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to `vDataframe` using the `to_vdf` method.

#### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.agg(["sum", "min"])

5 #Output
      sum      min
7 "age"    30062.0  0.33
8 "body"   19369.0  1.0
9 "passenger class" 2819.0  1.0
10 "parch"    467.0  0.0
11 "fare"   41877.3576  0.0
12 "sibsp"    622.0  0.0
13 "survived"  450.0  0.0
```

### 8.2.4.3 all

```
vDataframe.all(columns: list)
```

Aggregate the different columns by verifying if all the elements are True.

#### Parameters

- **columns:** *<list>*  
List of the `vDataframe` Columns.

## Returns

The `tablesample` type containing the aggregations (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to `vDataFrame` using the `to_vdf` method.

## Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "((SELECT True AS x, False AS y) UNION ALL (SELECT True AS x, True
    AS y)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5 #Output
      x      y
7 0   True  False
  1   True   True

9 vdf.all(['x', 'y'])

11 #Output
      bool_and
13 "x"         1.0
15 "y"         0.0

```

### 8.2.4.4 any

```

1 vDataFrame.any(columns: list)

```

Aggregate the different columns by verifying if at least one element is True.

## Parameters

- **columns:** *<list>*  
List of the `vDataFrame` Columns.

## Returns

The `tablesample` type containing the aggregations (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to `vDataFrame` using the `to_vdf` method.

## Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "((SELECT True AS x, False AS y) UNION ALL (SELECT True AS x, True
    AS y)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

```

```

5 #Output
      x      y
7 0   True   False
8 1   True    True
9
10 vdf.any(['x', 'y'])
11
12 #Output
      bool_or
13 "x"         1.0
14 "y"         1.0

```

#### 8.2.4.5 append

```

1 vDataframe.append(self, vdf = None, input_relation: str = "")

```

Merge the Virtual Dataframe with another one or an existing relation.

##### Parameters

- **vdf:** <vDataframe>, optional  
The Vertica Dataframe to merge with the current one.
- **input\_relation:** <str>, optional  
The input\_relation to merge with the Virtual Dataframe.

##### Returns

The Virtual Dataframe itself.

##### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
2 relation1 = "((SELECT 1 AS x, -1 AS y) UNION ALL (SELECT -3 AS x, -4 AS y)) z"
3 vdf1 = vdf_from_relation(relation1, dsn = "VerticaDSN")
4
5 #Output
      x      y
7 0     1     -1
8 1    -3     -4
9
10 Name: VDF, Number of rows: 2, Number of columns: 2
11
12 relation2 = "((SELECT 9 AS x, -3 AS y) UNION ALL (SELECT -1 AS x, 2 AS y)) z"
13 vdf2 = vdf_from_relation(relation2, dsn = "VerticaDSN")
14
15 #Output
      x      y

```

```

0      9      -3
17 1      -1      2
Name: VDF, Number of rows: 2, Number of columns: 2
19
vdf1.append(vdf = vdf2)
21
#Output
23      x      y
0      1      -1
25 1      -3      -4
2      9      -3
27 3      -1      2
Name: VDF, Number of rows: 4, Number of columns: 2

```

#### 8.2.4.6 apply

```
vDataframe.apply(self, func: dict)
```

Apply the input functions to the vDataframe columns.

##### Parameters

- **func:** <dict>  
Dictionary of the different columns with the functions to apply. The function's variable must be written using flower brackets '{}' (Example: EXP({}))

##### Returns

The Virtual Dataframe itself.

##### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT 1 AS x, 4 AS y) UNION ALL (SELECT 2 AS x, 9 AS y)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
5
#Output
6      x      y
7 0      1      4
8 1      2      9
9 Name: VDF, Number of rows: 2, Number of columns: 2
11
vdf.apply({'x': 'EXP({})', 'y': 'SQRT({})'})
13
#Output
14      x      y

```

```

15 0      2.71828182845905      2.0
16 1      7.38905609893065      3.0
17 Name: VDF, Number of rows: 2, Number of columns: 2

```

#### 8.2.4.7 applymap

```

1 vDataframe.applymap(self, func: str, numeric_only: bool = True)

```

Apply the corresponding function to all the vDataframe columns.

##### Parameters

- **func:** <str>  
The function to apply. The function's variable must be written using flower brackets '{}' (Example: EXP({}))
- **numeric\_only:** <bool>, optional  
Bool to apply the function only on the vDataframe numerical columns.

##### Returns

The Virtual Dataframe itself.

##### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
2 relation = "((SELECT 1 AS x, 4 AS y) UNION ALL (SELECT 2 AS x, 9 AS y)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
4
5 #Output
6
7      x      y
8 0      1      4
9 1      2      9
10 Name: VDF, Number of rows: 2, Number of columns: 2
11
12 vdf.applymap('EXP({})')
13
14 #Output
15
16      x      y
17 0      2.71828182845905      54.5981500331442
18 1      7.38905609893065      8103.08392757538
19 Name: VDF, Number of rows: 2, Number of columns: 2

```

#### 8.2.4.8 asfreq

```
vDataframe.asfreq(self, ts: str, rule: str, method: dict, by: list = [])
```

Slice the time series using a specific rules and a method for each column.

### Parameters

- **ts:** <str>  
The time series column to use.
- **rule:** <str>  
The slice rule to use (it must be an interval).
- **method:** <dict>  
A dictionary of different columns to use and the interpolation method to use. The method can be in {bfill (Back Propagation), ffill (First Element Propagation), linear (Linear Interpolation)}
- **by:** <list>, optional  
The columns used to group the elements.

### Returns

The Sliced Virtual Dataframe.

### Example

```
1 from vertica_ml_python.learn.datasets import load_smart_meters
2 sm = load_smart_meters(cur)
3 sm.sort(["id", "time"])
4
5 #Output
6
7      time      val      id
8 0  2014-01-01 11:00:00  0.0290000  0
9 1  2014-01-01 13:45:00  0.2770000  0
10 2  2014-01-02 10:45:00  0.3210000  0
11 3  2014-01-02 11:15:00  0.3050000  0
12 4  2014-01-02 13:45:00  0.3580000  0
13 ...      ...      ...      ...
14 Name: smart_meters, Number of rows: 11844, Number of columns: 3
15
16 sm.asfreq(ts = "time", rule = "5 minutes", method = {"val": "linear"}, by = ["
17      id"])
18
19 #Output
20
21      time      id      val
22 0  2014-01-01 11:00:00  0      0.029
23 1  2014-01-01 12:00:00  0  0.11918181818181818
24 2  2014-01-01 13:00:00  0  0.20936363636363636
25 3  2014-01-01 14:00:00  0  0.27752380952381
26 4  2014-01-01 15:00:00  0  0.279619047619048
```

```

...
...
...
25 Name: smart_meters, Number of rows: 148189, Number of columns: 3

```

#### 8.2.4.9 astype

```
1 vDataframe.astype(self, dtype: dict)
```

Convert the different columns to the input types.

##### Parameters

- **dtype:** <dict>  
A dictionary of different columns and the types to use for the conversion.

##### Returns

The Virtual Dataframe.

##### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT True AS x, 4 AS y) UNION ALL (SELECT False AS x, 9 AS y))
           z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5 #Output
           x      y
7 0      True      4
  1     False      9
9 Name: VDF, Number of rows: 2, Number of columns: 2

11 vdf.astype({"x": "int"})

13 #Output
           x      y
15 0        1      4
   1         0      9
17 Name: VDF, Number of rows: 2, Number of columns: 2

```

#### 8.2.4.10 at\_time

```
1 vDataframe.at_time(self, ts: str, time: str)
```

Filter the elements of the vDataframe by considering only the events happening at the exact time.

### Parameters

- **ts:** <str>  
The time series column to use.
- **time:** <str>  
The time to consider.

### Returns

The Virtual Dataframe itself.

### Example

```

1 from vertica_ml_python.learn.datasets import load_smart_meters
2 sm = load_smart_meters(cur)
3
4 #Output
5
6           time           val      id
7 0    2014-01-01 01:15:00    0.0370000    2
8 1    2014-01-01 02:30:00    0.0800000    5
9 2    2014-01-01 03:00:00    0.0810000    1
10 3    2014-01-01 05:00:00    1.4890000    3
11 4    2014-01-01 06:00:00    0.0720000    5
12 ...
13 Name: smart_meters, Number of rows: 11844, Number of columns: 3
14
15 sm.at_time(ts = "time", time = "12:00")
16
17 #Output
18
19           time           val      id
20 0    2014-01-04 12:00:00    0.0760000    2
21 1    2014-01-09 12:00:00    0.1610000    6
22 2    2014-01-15 12:00:00    0.0490000    9
23 3    2014-01-19 12:00:00    0.0200000    4
24 4    2014-01-21 12:00:00    0.1440000    7
25 ...
26 Name: smart_meters, Number of rows: 140, Number of columns: 3

```

#### 8.2.4.11 avg / mean

```
vDataframe.avg(columns: list = [])
```



Aggregate the different columns by computing the average of each one.

### Parameters

- **columns:** *<list>*, optional  
List of the vDataframe Columns. If this parameter is empty, all the numerical columns of the vDataframe will be aggregated.

### Returns

The `tablesample` type containing the avg (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.avg()

5 #Output
                                     avg
7 "age"                30.1524573721163
  "body"               164.14406779661
9 "survived"          0.364667747163695
  "pclass"             2.28444084278768
11 "parch"            0.378444084278768
   "fare"              33.9637936739659
13 "sibsp"            0.504051863857374

```

#### 8.2.4.12 bar

```

1 Dataframe.bar(
    self,
3     columns: list,
    method: str = "density",
5     of: str = "",
    max_cardinality: tuple = (6, 6),
7     h: tuple = (None, None),
    limit_distinct_elements: int = 200,
9     hist_type: str = "auto")

```

Draw the corresponding variables Bar Chart.

### Parameters

- **columns:** *<list>*  
List of the vDataframe Columns.

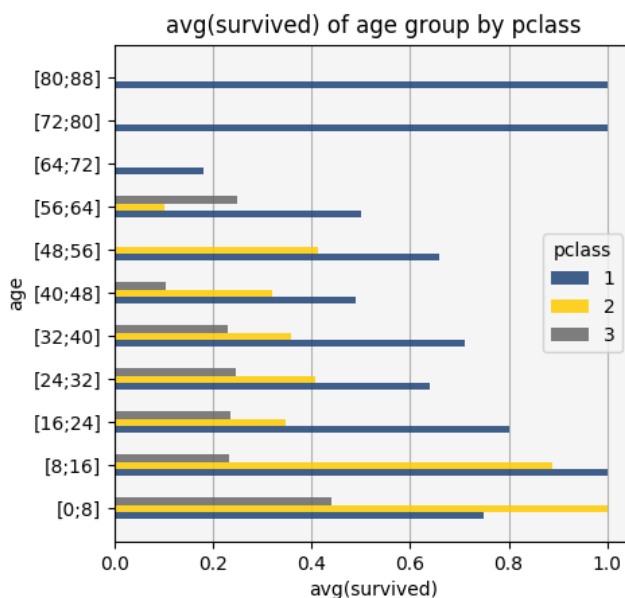
- **method:** *<str>*, optional  
count | density | avg | min | max | sum  
count (default): count is used as aggregation  
density: density is used as aggregation  
avg | min | max | sum: these aggregations are used only if "of" is informed
- **of:** *<str>*, optional  
The column used to compute the aggregation. This parameter is used only if "method" in {avg | min | max | sum}
- **max\_cardinality:** *<tuple>*, optional  
The maximum cardinality of each column. Under this number the column is automatically considered as categorical.
- **h:** *<tuple>*, optional  
The interval size of each column. It is used if the column is numerical. In the other case, if h is not informed. The best "h" will be computed automatically.
- **limit\_distinct\_elements:** *<int>*, optional  
The maximum number of distinct elements. The other categories will be ignored.
- **hist\_type:** *<positive int>*, optional  
The Bar Chart type. It can be in {fully\_stacked | stacked | auto}

## Returns

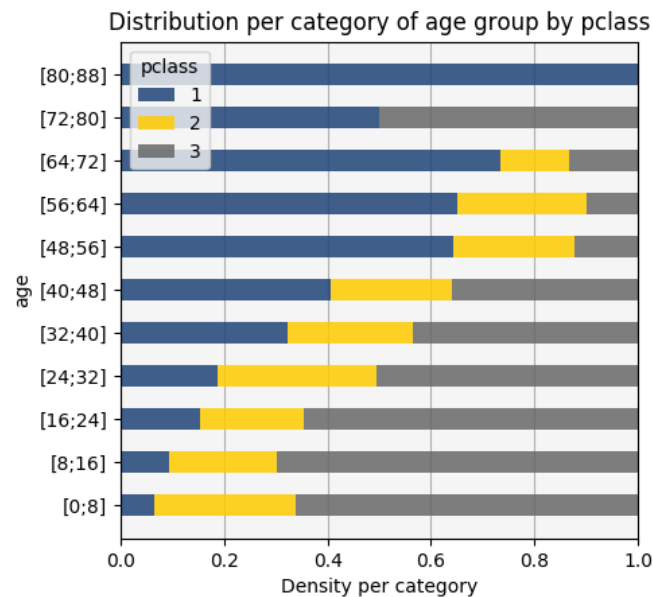
The vDataFrame itself.

## Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
   titanic = load_titanic(cur)
3 titanic.bar(columns = ["age", "pclass"], method = "avg", of = "survived")
```



```
1 titanic.bar(columns = ["age", "pclass"], method = "density", hist_type = "
    fully_stacked")
```



#### 8.2.4.13 beta

```
1 vDataframe.beta(columns: list = [])
```

Compute the beta matrix of the corresponding vDataframe columns.

#### Parameters

- **columns:** *<list>*, optional  
List of the vDataframe columns. If this parameter is empty, the method will consider all the numerical columns.

#### Returns

The `tablesampl` type containing the matrix (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

#### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.beta(columns = ["age", "fare", "pclass"])

5 #Output
```

"age"
"fare"
"pclass"

```

7 "age"          1          0.696124885853721          -0.0234150242013145
  "fare"        1.4365238484091967          1          -0.00898230868463811
9  "pclass"      -42.70762188423708          -111.3299525889417          1

```

#### 8.2.4.14 between\_time

```

1 vDataframe.between_time(self, ts: str, start_time: str, end_time: str)

```

Filter the elements of the vDataframe by considering only the events happening at the time range.

#### Parameters

- **ts:** <str>  
The time series column to use.
- **start\_time:** <str>  
The start time.
- **end\_time:** <str>  
The end time.

#### Returns

The Virtual Dataframe itself.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_smart_meters
  sm = load_smart_meters(cur)
3
4 #Output
5
6           time          val      id
7 0    2014-01-01 01:15:00    0.0370000    2
8 1    2014-01-01 02:30:00    0.0800000    5
9 2    2014-01-01 03:00:00    0.0810000    1
10 3    2014-01-01 05:00:00    1.4890000    3
11 4    2014-01-01 06:00:00    0.0720000    5
12 ...          ...          ...      ...
13 Name: smart_meters, Number of rows: 11844, Number of columns: 3
14
15 sm.between_time(ts = "time", start_time = "12:00", end_time = "14:00")
16
17 #Output
18
19           time          val      id
20 0    2014-01-01 13:00:00    0.6220000    4
21 1    2014-01-01 13:45:00    0.2770000    0
22 2    2014-01-02 12:30:00    0.3970000    5

```

```

21 3      2014-01-02 13:45:00      0.3580000      0
    4      2014-01-03 12:15:00      0.1030000      8
23 ...      ...      ...      ...
    Name: smart_meters, Number of rows: 1151, Number of columns: 3

```

#### 8.2.4.15 boxplot

```
vDataframe.boxplot(self, columns: list = [])
```

Draw the Boxplot of the different vDataframe columns.

##### Parameters

- **columns:** <list>, optional  
List of the vDataframe columns. If this parameter is empty, the method will consider all the numerical columns.

##### Returns

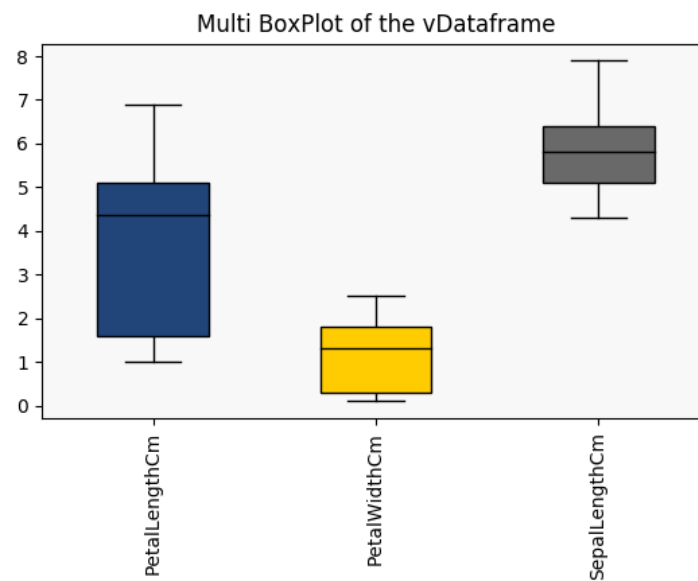
The Virtual Dataframe itself.

##### Example

```

1 from vertica_ml_python.learn.datasets import load_iris
  iris = load_iris(cur)
3 iris.boxplot(columns = ["PetalLengthCm", "PetalWidthCm", "SepalLengthCm"])

```



#### 8.2.4.16 catcol

```
1 vDataframe.catcol(self, max_cardinality: int = 12)
```

Returns all the different vDataframe categorical columns.

##### Parameters

- **max\_cardinality:** *<int>*, optional  
The maximum cardinality of each column. Under this number the column is automatically considered as categorical.

##### Returns

List of all the categorical columns.

##### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.catcol()

5 #Output
  ['survived', 'sex', 'pclass', 'embarked', 'parch', 'sibsp']
```

#### 8.2.4.17 copy

```
vDataframe.copy(self)
```

Return a copy of the vDataframe.

##### Returns

The copy of the vDataframe.

##### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic2 = titanic.copy() # titanic2 is now a copy of titanic
```

#### 8.2.4.18 corr

```
1 vDataframe.corr(  
    self,  
3     columns: list = [],  
     method: str = "pearson",  
5     cmap: str = "",  
     round_nb: int = 3,  
7     show: bool = True)
```

Compute the correlation matrix of the vDataframe.

##### Parameters

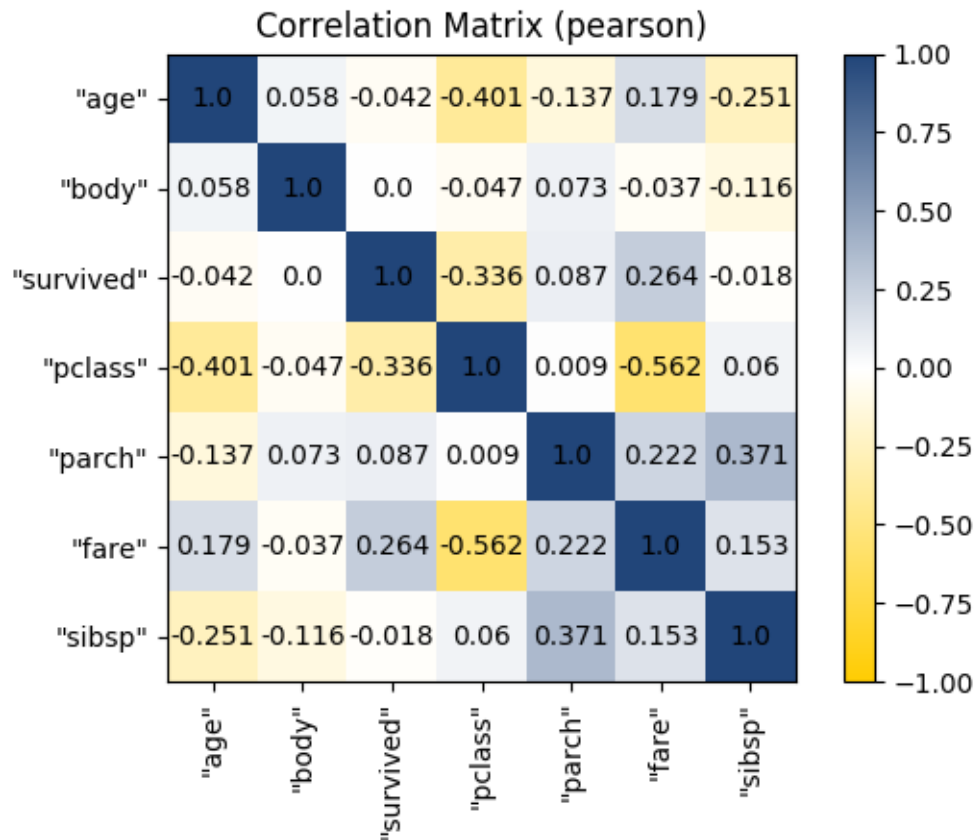
- **columns:** *<list>*, optional  
List of the vDataframe columns. If this parameter is empty, the method will consider all the numerical columns.
- **method:** *<str>*, optional  
The method must be in pearson (Pearson Coefficient) | kendall (Kendall Coefficient) | spearman (Spearman Coefficient) | biserial (Biserial Point) | cramer (Cramer'sV)
- **cmap:** *<str>*, optional  
Color Maps.
- **round\_nb:** *<int>*, optional  
Integer used to round the numerical values.
- **show:** *<bool>*, optional  
Display the result using matplotlib.

##### Returns

The `tablesampl` type containing the matrix (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

##### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic  
titanic = load_titanic(cur)  
3 titanic.corr()
```



#### 8.2.4.19 cov

```
vDataframe.cov(self, columns: list = [])
```

Compute the covariance matrix of the vDataframe.

#### Parameters

- **columns:** *<list>*, optional  
List of the vDataframe columns. If this parameter is empty, the method will consider all the numerical columns.

#### Returns

The `tablesamle` type containing the matrix (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

#### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
3 titanic.cov(columns = ["survived", "age", "fare"])
```



```

5 #Output
7
8
9

```

	"survived"	"age"	"fare"
"survived"	0.231685181342251	-0.297583583247234	6.69214075159394
"age"	-0.297583583247234	208.169014723609	145.057125218791
"fare"	6.69214075159394	145.057125218791	2769.36114247479

#### 8.2.4.20 count

```

1 vDataframe.count(self, columns: list = [], percent: bool = True)

```

Aggregate the different columns by computing the count (number of non-NULL element) of each one.

#### Parameters

- **columns:** *<list>*, optional  
List of the vDataframe Columns. If this parameter is empty, the method will consider all the numerical columns.
- **percent:** *<list>*, optional  
If true, compute the percent of non-NULL value of each column.

#### Returns

The `tablesampl` type containing the counts (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
3 titanic.count()
4
5 #Output
6
7
8
9
10
11
12
13
14
15
16
17
18
19

```

	count	percent
"age"	997.0	80.794
"body"	118.0	9.562
"survived"	1234.0	100.0
"ticket"	1234.0	100.0
"home.dest"	706.0	57.212
"cabin"	286.0	23.177
"sex"	1234.0	100.0
"pclass"	1234.0	100.0
"embarked"	1232.0	99.838
"parch"	1234.0	100.0
"fare"	1233.0	99.919
"name"	1234.0	100.0
"boat"	439.0	35.575

"sibsp"	1234.0	100.0
---------	--------	-------

#### 8.2.4.21 cummax

```

vDataframe.cummax(
    self,
    name: str,
    column: str,
    by: list = [],
    order_by: list = [])

```

Add a new column to the vDataframe which is the cumulative max of another one.

#### Parameters

- **name:** <str>  
Name of the new feature.
- **column:** <str>  
The column used to compute the cumulative max.
- **by:** <list>, optional  
The columns used to group the vDataframe elements.
- **order\_by:** <list>, optional  
The columns used to order the vDataframe elements. If it is empty, the vDataframe will be ordered by the input column.

#### Returns

The vDataframe itself.

#### Example

```

from vertica_ml_python.learn.datasets import load_smart_meters
sm = load_smart_meters(cur)
sm.cummax(name = "val_cummax", column = "val", by = ["id"], order_by = ["time"]
    ))

```

#Output

	time	val	id	val_cummax
0	2014-01-01 11:00:00	0.0290000	0	0.0290000
1	2014-01-01 13:45:00	0.2770000	0	0.2770000
2	2014-01-02 10:45:00	0.3210000	0	0.3210000
3	2014-01-02 11:15:00	0.3050000	0	0.3210000
4	2014-01-02 13:45:00	0.3580000	0	0.3580000
5	2014-01-02 15:30:00	0.1150000	0	0.3580000
6	2014-01-03 08:30:00	0.0710000	0	0.3580000

```

14 7      2014-01-04 23:45:00      0.3230000      0      0.3580000
15 8      2014-01-06 01:15:00      0.0850000      0      0.3580000
16 9      2014-01-06 21:45:00      0.7130000      0      0.7130000
17 ...      ...      ...      ...      ...
18 Name: smart_meters, Number of rows: 11844, Number of columns: 4

```

#### 8.2.4.22 cummin

```

vDataframe.cummin(
2     self,
    name: str,
4     column: str,
    by: list = [],
6     order_by: list = [])

```

Add a new column to the vDataframe which is the cumulative min of another one.

#### Parameters

- **name:** <str>  
Name of the new feature.
- **column:** <str>  
The column used to compute the cumulative min.
- **by:** <list>, optional  
The columns used to group the vDataframe elements.
- **order\_by:** <list>, optional  
The columns used to order the vDataframe elements. If it is empty, the vDataframe will be ordered by the input column.

#### Returns

The vDataframe itself.

#### Example

```

from vertica_ml_python.learn.datasets import load_smart_meters
2 sm = load_smart_meters(cur)
sm.cummin(name = "val_cummin", column = "val", by = ["id"], order_by = ["time"
4     ])
#Output
6
    time      val      id      val_cummin
0      2014-01-01 11:00:00      0.0290000      0      0.0290000
8 1      2014-01-01 13:45:00      0.2770000      0      0.0290000
2 2      2014-01-02 10:45:00      0.3210000      0      0.0290000

```

```

10 3      2014-01-02 11:15:00      0.3050000      0      0.0290000
12 4      2014-01-02 13:45:00      0.3580000      0      0.0290000
14 5      2014-01-02 15:30:00      0.1150000      0      0.0290000
16 6      2014-01-03 08:30:00      0.0710000      0      0.0290000
18 7      2014-01-04 23:45:00      0.3230000      0      0.0290000
   8      2014-01-06 01:15:00      0.0850000      0      0.0290000
   9      2014-01-06 21:45:00      0.7130000      0      0.0290000
   ...      ...      ...      ...      ...
18 Name: smart_meters, Number of rows: 11844, Number of columns: 4

```

#### 8.2.4.23 cumprod

```

vDataframe.cumprod(
2     self,
4     name: str,
6     column: str,
    by: list = [],
    order_by: list = [])

```

Add a new column to the vDataframe which is the cumulative product of another one.

#### Parameters

- **name:** <str>  
Name of the new feature.
- **column:** <str>  
The column used to compute the cumulative product.
- **by:** <list>, optional  
The columns used to group the vDataframe elements.
- **order\_by:** <list>, optional  
The columns used to order the vDataframe elements. If it is empty, the vDataframe will be ordered by the input column.

#### Returns

The vDataframe itself.

#### Example

```

from vertica_ml_python.learn.datasets import load_smart_meters
2 sm = load_smart_meters(cur)
sm.cumprod(name = "val_cumprod", column = "val", by = ["id"], order_by = ["
4     time"])
#Output

```

```

6      time      val      id      val_cumprod
0      2014-01-01 11:00:00  0.0290000  0      0.029
8      1      2014-01-01 13:45:00  0.2770000  0      0.008033
2      2      2014-01-02 10:45:00  0.3210000  0      0.002578593
10     3      2014-01-02 11:15:00  0.3050000  0      0.000786470865
4      4      2014-01-02 13:45:00  0.3580000  0      0.00028155656967
12     5      2014-01-02 15:30:00  0.1150000  0      3.237900551205e-05
6      6      2014-01-03 08:30:00  0.0710000  0      2.29890939135555e-06
14     7      2014-01-04 23:45:00  0.3230000  0      7.42547733407843e-07
8      8      2014-01-06 01:15:00  0.0850000  0      6.31165573396666e-08
16     9      2014-01-06 21:45:00  0.7130000  0      4.50021053831823e-08
...
18 Name: smart_meters, Number of rows: 11844, Number of columns: 4

```

#### 8.2.4.24 cumsum

```

vDataframe.cumsum(
2     self,
      name: str,
4     column: str,
      by: list = [],
6     order_by: list = [])

```

Add a new column to the vDataframe which is the cumulative sum of another one.

#### Parameters

- **name:** <str>  
Name of the new feature.
- **column:** <str>  
The column used to compute the cumulative sum.
- **by:** <list>, optional  
The columns used to group the vDataframe elements.
- **order\_by:** <list>, optional  
The columns used to order the vDataframe elements. If it is empty, the vDataframe will be ordered by the input column.

#### Returns

The vDataframe itself.

#### Example

```

from vertica_ml_python.learn.datasets import load_smart_meters
2 sm = load_smart_meters(cur)

```

```

sm.cumsum(name = "val_cumsum", column = "val", by = ["id"], order_by = ["time"]
))
4
#Output
6
      time      val      id      val_cumsum
0  2014-01-01 11:00:00  0.0290000  0      0.0290000
8  1  2014-01-01 13:45:00  0.2770000  0      0.3060000
2  2  2014-01-02 10:45:00  0.3210000  0      0.6270000
10 3  2014-01-02 11:15:00  0.3050000  0      0.9320000
4  4  2014-01-02 13:45:00  0.3580000  0      1.2900000
12 5  2014-01-02 15:30:00  0.1150000  0      1.4050000
6  6  2014-01-03 08:30:00  0.0710000  0      1.4760000
14 7  2014-01-04 23:45:00  0.3230000  0      1.7990000
8  8  2014-01-06 01:15:00  0.0850000  0      1.8840000
16 9  2014-01-06 21:45:00  0.7130000  0      2.5970000
...
18 Name: smart_meters, Number of rows: 11844, Number of columns: 4

```

#### 8.2.4.25 current\_relation

```
vDataframe.current_relation(self)
```

#### Returns

Returns the vDataframe current relation.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
titanic = load_titanic(cur)
3 titanic["age"].fillna()
titanic.current_relation()
5
#Output
7 (SELECT COALESCE("age", 30.1524573721163) AS "age", "body" AS "body", "
    survived" AS "survived", "ticket" AS "ticket", "home.dest" AS "home.dest",
    "cabin" AS "cabin", "sex" AS "sex", "pclass" AS "pclass", "embarked" AS "
embarked", "parch" AS "parch", "fare" AS "fare", "name" AS "name", "boat"
AS "boat", "sibsp" AS "sibsp" FROM (SELECT "age" AS "age", "body" AS "body",
"survived" AS "survived", "ticket" AS "ticket", "home.dest" AS "home.
dest", "cabin" AS "cabin", "sex" AS "sex", "pclass" AS "pclass", "embarked"
AS "embarked", "parch" AS "parch", "fare" AS "fare", "name" AS "name", "
boat" AS "boat", "sibsp" AS "sibsp" FROM public.titanic) t1) final_table

```

#### 8.2.4.26 datecol

```
1 vDataframe.datecol(self)
```

Returns all the timestamps columns.

### Returns

List of all the timestamps columns.

### Example

```
1 from vertica_ml_python.learn.datasets import load_smart_meters
  sm = load_smart_meters(cur)
3 sm.datecol()

5 #Output
  ['time']
```

#### 8.2.4.27 describe

```
1 vDataframe.describe(
2     self,
3     method: str = "numerical",
4     columns: list = [],
5     unique: bool = True)
```

Summarise the dataset with mathematical information.

### Parameters

- **method:** *<str>*, optional  
numerical | categorical  
numerical (default): This mode is used to have only numerical information. Other types are ignored.  
categorical: This mode is available for any type.
- **columns:** *<list>*, optional  
The columns used to compute the mathematical information. If this parameter is empty, the method will consider all the vDataframe columns when the method is 'categorical' otherwise it will only consider the numerical columns.
- **unique:** *<bool>*, optional  
Include the cardinality of each element in the computation

### Returns

The `tablesample` type containing the mathematical information (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3
4 #numerical
5 titanic.describe()
6
7 #Output
8
9      count      mean      std  \
age      997      30.1524573721163      14.4353046299159  \
body     118      164.14406779661      96.5760207557808  \
11 fare    1233      33.963793673966      52.6460729831293  \
parch    1234      0.378444084278768      0.868604707790393  \
13 pclass   1234      2.28444084278768      0.842485636190292  \
sibsp    1234      0.504051863857374      1.04111727241629  \
15 survived 1234      0.364667747163696      0.481532018641288  \
      min      25%      50%      75%  \
17 age      0.33      21.0      28.0      39.0  \
body      1.0      79.25      160.5      257.5  \
19 fare      0.0      7.8958      14.4542      31.3875  \
parch      0.0      0.0      0.0      0.0  \
21 pclass     1.0      1.0      3.0      3.0  \
sibsp      0.0      0.0      0.0      1.0  \
23 survived 0.0      0.0      0.0      1.0  \
24
25 #categorical
  titanic.describe(method = "categorical")
26
27 #Output
28
29      dtype  unique  count  \
"age"      numeric(6,3)      96      997  \
31 "body"      int      118      118  \
  "survived"      int      2      1234  \
33 "ticket"     varchar(36)      887      1234  \
  "home.dest"     varchar(100)      359      706  \
35 "cabin"      varchar(30)      182      286  \
  "sex"          varchar(20)      2      1234  \
37 "pclass"      int      3      1234  \
  "embarked"     varchar(20)      3      1232  \
39 "parch"      int      8      1234  \
  "fare"         numeric(10,5)      277      1233  \
41 "name"        varchar(164)      1232      1234  \
  "boat"         varchar(100)      26      439  \
43 "sibsp"      int      7      1234  \
      top  top_percent
45 "age"      24.000      4.413
  "body"      1      0.847

```



```

47 "survived"                0                63.533
   "ticket"                CA. 2343          0.81
49 "home.dest"             New York, NY      8.782
   "cabin"                 C23 C25 C27       2.098
51 "sex"                   male             65.964
   "pclass"                3                53.728
53 "embarked"              S                70.86
   "parch"                 0                76.904
55 "fare"                  8.05000          4.704
   "name"                  Connolly, Miss. Kate 0.162
57 "boat"                  13                8.428
   "sibsp"                 0                67.747

```

#### 8.2.4.28 drop

```
vDataframe.drop(self, columns: list = [])
```

Drop the selected columns from the vDataframe.

#### Parameters

- **columns:** *<list>*, optional  
List of the vDataframe columns.

#### Returns

The vDataframe itself.

#### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "((SELECT True AS x, 4 AS y) UNION ALL (SELECT False AS x, 9 AS y))
              z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5 #Output
      x      y
7 0    True    4
  1  False    9
9 Name: VDF, Number of rows: 2, Number of columns: 2

11 vdf.drop(["x"])

13 #Output
      y
15 0    4

```

```

1      9
17 Name: y, Number of rows: 2, dtype: int

```

#### 8.2.4.29 drop\_duplicates

```

1 vDataframe.drop_duplicates(self, columns: list = [])

```

Drop the vDataframe duplicates (the duplicates are defined according to specific columns of the vDataframe).

##### Parameters

- **columns:** <list>, optional  
List of the vDataframe columns.

##### Returns

The vDataframe itself.

##### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT 1 AS x, 4 AS y) UNION ALL (SELECT 1 AS x, 4 AS y) UNION
      ALL (SELECT 1 AS x, 5 AS y)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5 #Output
      x      y
7 0      1      4
  1      1      4
9 2      1      5
Name: VDF, Number of rows: 3, Number of columns: 2

11 vdf.drop_duplicates()

13 #Output
      x      y
15 0      1      4
17 1      1      5
Name: VDF, Number of rows: 2, Number of columns: 2

```

#### 8.2.4.30 dropna

```

vDataframe.dropna(self, columns: list = [])

```

Drop the vDataFrame missing values.

### Parameters

- **columns:** *<list>*, optional  
List of the vDataFrame columns to consider. If this parameter is empty, it will filter all the rows having at least one missing element.

### Returns

The vDataFrame itself.

### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "((SELECT 1 AS x, NULL AS y) UNION ALL (SELECT 1 AS x, 4 AS y)
              UNION ALL (SELECT 1 AS x, 5 AS y)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5 #Output
      x      y
7 0    1  None
  1    1    4
  2    1    5
9 Name: VDF, Number of rows: 3, Number of columns: 2

11 vdf.dropna()

13 #Output
      x      y
15 0    1    4
17 1    1    5
  Name: VDF, Number of rows: 2, Number of columns: 2

```

#### 8.2.4.31 dsn\_restart

```
vDataFrame.dsn_restart(self)
```

Set a new vDataFrame cursor connection using the stored DSN. This method is useful if the connection to the Vertica DB failed.

#### 8.2.4.32 dtypes

```
vDataFrame.dtypes(self)
```

Returns all the vDataframe columns types.

### Returns

The `tablesample` type containing the columns types (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.dtypes()

5 #Output
                                dtype
7 "age"                numeric(6,3)
  "body"                  int
9 "survived"            int
  "ticket"              varchar(36)
11 "home.dest"         varchar(100)
  "cabin"               varchar(30)
13 "sex"               varchar(20)
  "pclass"              int
15 "embarked"          varchar(20)
  "parch"              int
17 "fare"              numeric(10,5)
  "name"               varchar(164)
19 "boat"              varchar(100)
  "sibsp"              int

```

#### 8.2.4.33 duplicated

```
vDataframe.duplicated(self, columns: list = [], count: bool = False)
```

Find all the vDataframe duplicates (the duplicates are defined according to specific columns of the vDataframe).

### Parameters

- **columns:** *<list>*, optional  
List of the vDataframe columns.
- **count:** *<bool>*, optional  
If True, the function will return the number of duplicates.

### Returns

The `tablesample` type containing the duplicates (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to `vDataframe` using the `to_vdf` method.

### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "((SELECT 1 AS x, 4 AS y) UNION ALL (SELECT 1 AS x, 4 AS y) UNION
              ALL (SELECT 1 AS x, 5 AS y)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5 #Output
      x    y
7 0    1    4
  1    1    4
9 2    1    5
Name: VDF, Number of rows: 3, Number of columns: 2

11 vdf.duplicated()

13 #Output
      x    y  occurrence
15 0    1    4           2
17 Name: Duplicated Rows, Number of rows: 1, Number of columns: 3

```

#### 8.2.4.34 empty

```
1 vDataframe.empty(self)
```

Returns True if the `vDataframe` is empty.

#### 8.2.4.35 eval

```
1 vDataframe.eval(self, name: str, expr: str)
```

Evaluate an expression and create a new column if the expression is correct.

#### Parameters

- **name:** `<str>`  
Name of the new column
- **expr:** `<str>`  
The expression used to create the new column

## Returns

The vDataFrame itself.

## Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT 2 AS x, 4 AS y) UNION ALL (SELECT 3 AS x, 4 AS y) UNION
      ALL (SELECT 10 AS x, 5 AS y)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5
#Output
7      x      y
0      2      4
9      3      4
2     10      5
11 Name: VDF, Number of rows: 3, Number of columns: 2

13 vdf.eval("z", "x * y")

15 #Output
17      x      y      z
0      2      4      8
1      3      4     12
19     10      5     50
Name: VDF, Number of rows: 3, Number of columns: 3

```

### 8.2.4.36 expected\_store\_usage

```
vDataFrame.expected_store_usage(self, unit = 'b')
```

Expected data volume if the final relation is stored in the Database.

## Parameters

- **unit:** <str>, optional  
Storage Unit, can be in {b | kb | mb | gb | tb}

## Returns

The `tablesamples` type containing the expected store usage of each column (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataFrame using the `to_vdf` method.

## Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.expected_store_usage(unit = 'kb')

5 #Output
      expected_size (kb)    max_size (kb)    type
7 "age"                0.0087890625    8.7626953125    numeric(6,3)
  "body"                0.306640625      7.375          int
9 "survived"           1.205078125      77.125         int
  "ticket"              8.2001953125     43.3828125     varchar(36)
11 "home.dest"         13.130859375     68.9453125     varchar(100)
  "cabin"               1.0390625       8.37890625     varchar(30)
13 "sex"               5.640625        24.1015625     varchar(20)
  "pclass"              1.205078125      77.125         int
15 "embarked"           1.203125        24.0625        varchar(20)
  "parch"               1.205078125      77.125         int
17 "fare"              0.0146484375    18.0615234375  numeric(10,5)
  "name"               31.9521484375    197.6328125    varchar(164)
19 "boat"              0.6318359375    42.87109375    varchar(100)
  "sibsp"              1.205078125      77.125         int
21 separator           16.87109375     16.87109375
  header               0.11328125      0.11328125
23 rawsize             83.9326171875    769.05859375

```

#### 8.2.4.37 fillna

```

1 vDataframe.fillna(
      self,
3      val: dict = {},
      method: dict = {},
5      numeric_only: bool = False)

```

Fill the missing values using the input methods. If the parameters `val` and `method` are empty, all the missing values will be filled automatically (using the average of the column for the numerical columns and the mode for the categorical ones)

#### Parameters

- **val:** *<dict>*, optional  
Dictionary of columns with the constant value used to fill their missing values.
- **method:** *<dict>*, optional  
Dictionary of columns with the method used to fill their missing values. The method can be in {avg | median | mode}. For more flexibility, use the method `fillna` of the `vColumn`.
- **numeric\_only:** *<bool>*, optional  
If true, only the numerical columns will be filled

## Returns

The vDataFrame itself.

## Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT 2 AS x, NULL AS y) UNION ALL (SELECT NULL AS x, 4 AS y)
      UNION ALL (SELECT 10 AS x, 5 AS y)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5
#Output
7      x      y
0      2    None
9    None      4
1     10      5
11 Name: VDF, Number of rows: 3, Number of columns: 2

13 vdf.fillna()

15 #Output
17      x      y
0     2.0    4.5
1     6.0    4.0
19    10.0    5.0
Name: VDF, Number of rows: 3, Number of columns: 2

```

### 8.2.4.38 filter

```
vDataFrame.filter(self, expr: str = "", conditions: list = [])
```

Filter the elements of the vDataFrame using an expression or multiple conditions.

## Parameters

- **val:** *<expr>*, optional  
The expression used to filter the data.
- **conditions:** *<list>*, optional  
A list of conditions used to filter the data.

## Returns

The vDataFrame itself.

## Example



```

1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "((SELECT 2 AS x, 1 AS y) UNION ALL (SELECT 10 AS x, 4 AS y) UNION
              ALL (SELECT 10 AS x, 5 AS y)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5 #Output
      x      y
7 0      2      1
  1     10      4
9 2     10      5
Name: VDF, Number of rows: 3, Number of columns: 2

11 vdf.filter(expr = "x = 10")

13 #Output
      x      y
15 0     10      4
17 1     10      5
Name: VDF, Number of rows: 2, Number of columns: 2

```

#### 8.2.4.39 first

```
vDataframe.first(self, ts: str, offset: str)
```

Keep only the first events of the specific time series.

##### Parameters

- **ts:** <str>  
The time series column.
- **offset:** <list>, optional  
The offset time interval used to filter the data.

##### Returns

The vDataframe itself.

##### Example

```

1 from vertica_ml_python.learn.datasets import load_smart_meters
  sm = load_smart_meters(cur)
3 # We only keep the first day of the dataset
  sm.first(ts = "time", offset = "1 day")
5
#Output

```

```

7      time      val      id
9 0    2014-01-01 01:15:00  0.0370000  2
10 1    2014-01-01 02:30:00  0.0800000  5
11 2    2014-01-01 03:00:00  0.0810000  1
12 3    2014-01-01 05:00:00  1.4890000  3
13 4    2014-01-01 06:00:00  0.0720000  5
...      ...      ...      ...
Name: smart_meters, Number of rows: 20, Number of columns: 3

```

#### 8.2.4.40 get\_columns

```
vDataframe.get_columns(self)
```

Returns the vDataframe columns.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_smart_meters
  sm = load_smart_meters(cur)
3 sm.get_columns()

5 #Output
  ["time", "val", "id"]

```

#### 8.2.4.41 groupby

```
vDataframe.groupby(self, columns: list, expr: list = [])
```

Group the different categories of the input columns and compute the different aggregations.

#### Parameters

- **columns:** *<list>*  
List of the columns to group with.
- **expr:** *<list>*, optional  
List of the different aggregations to apply.

#### Returns

A new vDataframe corresponding to the group-by result.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.groupby(columns = ["pclass"], expr = ["AVG(survived)", "COUNT(*)"])

5 #Output
      pclass          AVG    COUNT
7 0         1    0.612179487179487    312
  1         2    0.416988416988417    259
9 2         3    0.227752639517345    663
Name: titanic, Number of rows: 3, Number of columns: 3

```

#### 8.2.4.42 head

```
vDataframe.head(self, limit: int = 5)
```

Returns the vDataframe first elements.

##### Parameters

- **limit:** <int>  
The number of elements to return.

##### Returns

The `tablesampl` type containing the head of the vDataframe (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

##### Example

```

1 from vertica_ml_python.learn.datasets import load_smart_meters
  sm = load_smart_meters(cur)
3 sm.head(limit = 10)

5 #Output
      time          val    id
7 0  2014-01-01 01:15:00    0.0370000    2
  1  2014-01-01 02:30:00    0.0800000    5
9 2  2014-01-01 03:00:00    0.0810000    1
  3  2014-01-01 05:00:00    1.4890000    3
11 4  2014-01-01 06:00:00    0.0720000    5
   5  2014-01-01 07:15:00    2.3060000    9
13 6  2014-01-01 07:45:00    0.1020000    4
   7  2014-01-01 10:45:00    0.0970000    8
15 8  2014-01-01 11:00:00    0.0290000    0
   9  2014-01-01 11:00:00    0.5060000    6

```

```

17 ...                ...                ...
Name: smart_meters, Number of rows: 11844, Number of columns: 3

```

#### 8.2.4.43 help

```
vDataframe.help(self)
```

Prints information about the vDataframe.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.help()

5 #Output

7 #####
  #
9 # Vertica Virtual Dataframe #
  #
11 #####

13 The vDataframe is a Python object which will keep in mind all the user
  modifications in order to use an optimised SQL query. It will send the
  query to the database which will use its aggregations to compute fast
  results. It is created using a view or a table stored in the user database
  and a database cursor. It will create for each column of the table a
  vColumn (Vertica Virtual Column) which will store for each column its name
  , its imputations and allows to do easy modifications and explorations.

15 vColumn and vDataframe coexist and one can not live without the other. vColumn
  will use the vDataframe information and reciprocally. It is imperative to
  understand both structures to know how to use the entire object.

17 When the user imputes or filters the data, the vDataframe gets in memory all
  the transformations to select for each query the needed data in the input
  relation.

19 As the vDataframe will try to keep in mind where the transformations occurred
  in order to use the appropriate query, it is highly recommended to save
  the vDataframe when the user has done a lot of transformations in order to
  gain in efficiency (using the save method). We can also see all the
  modifications using the history method.

```

```

21 If you find any difficulties using vertica_ml_python, please contact me: badr.
    ouali@microfocus.com / I'll be glad to help.
23 For more information about the different methods or the entire vDataframe
    structure, please see the entire documentation

```

#### 8.2.4.44 hexbin

```

1 vDataframe.hexbin(
    self,
3     columns: list,
    method: str = "count",
5     of: str = "",
    cmap: str = '',
7     gridsize: int = 10,
    color: str = "white")

```

Draw the corresponding Hexbin plot.

#### Parameters

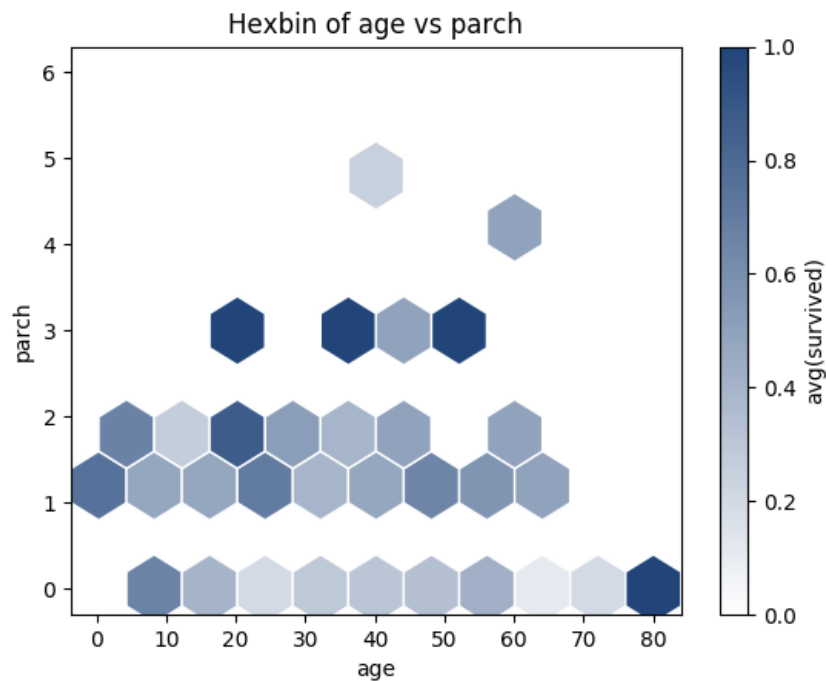
- **columns:** *<list>*  
The two columns used to draw the hexbin (first will be on the x-axis and the second in the y-axis)
- **method:** *<str>*, optional  
count | density | avg | min | max | sum  
count (default): count is used as aggregation  
density: density is used as aggregation  
avg | min | max | sum: these aggregations are used only if "of" is informed
- **of:** *<str>*, optional  
The column used to compute the aggregation. This variable is used only if "method" in {avg | min | max | sum}
- **cmap:** *<str>*, optional  
Color Maps.
- **gridsize:** *<int>*, optional  
Grid Size.
- **color:** *<str>*, optional  
Hexbin outline color.

#### Example

```

from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
titanic.hexbin(columns = ["age", "parch"], method = "avg", of = "survived")

```



#### 8.2.4.45 hist

```

1 DataFrame.hist(
2     self,
3     columns: list,
4     method: str = "density",
5     of: str = "",
6     max_cardinality: tuple = (6, 6),
7     h: tuple = (None, None),
8     limit_distinct_elements: int = 200,
9     hist_type: str = "auto")

```

Draw the corresponding variables Histogram.

#### Parameters

- **columns:** <list>  
List of the vDataFrame columns.
- **method:** <str>, optional  
count | density | avg | min | max | sum  
count (default): count is used as aggregation  
density: density is used as aggregation  
avg | min | max | sum: these aggregations are used only if "of" is informed
- **of:** <str>, optional  
The column used to compute the aggregation. This parameter is used only if "method" in {avg | min | max | sum}

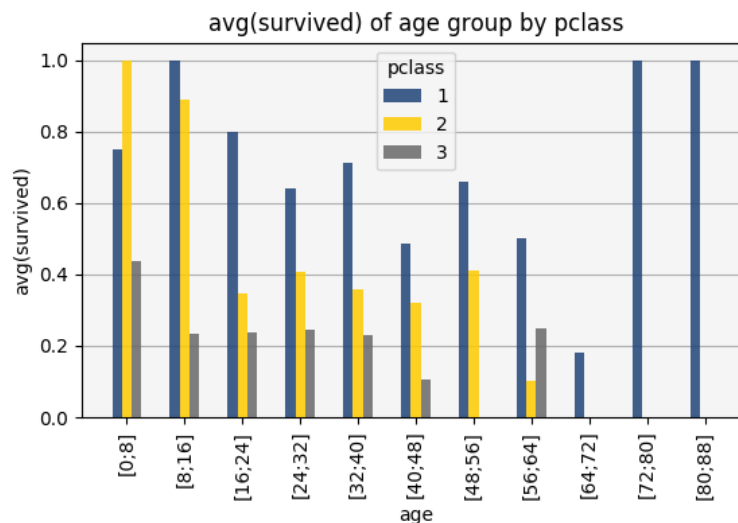
- **max\_cardinality:** *<tuple>*, optional  
The maximum cardinality of each column. Under this number the column is automatically considered as categorical.
- **h:** *<tuple>*, optional  
The interval size of each column. It is used if the column is numerical. In the other case, if h is not informed. The best "h" will be computed automatically.
- **limit\_distinct\_elements:** *<int>*, optional  
The maximum number of distinct elements. The other categories will be ignored.
- **hist\_type:** *<positive int>*, optional  
The Histogram type. It can be in {multi | stacked | auto}

## Returns

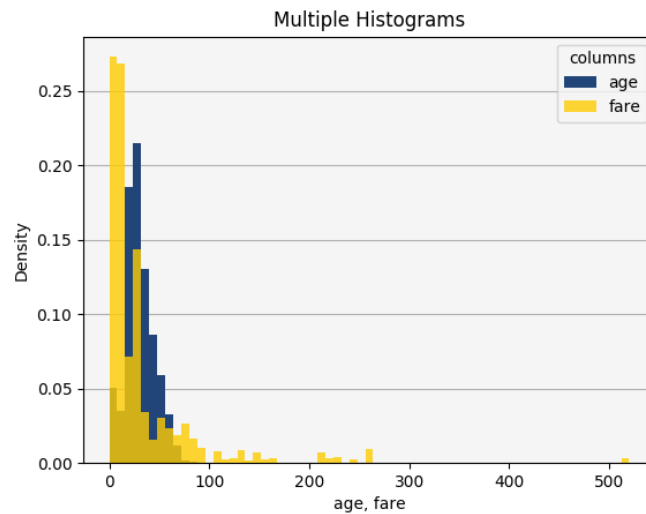
The vDataFrame itself.

## Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
   titanic = load_titanic(cur)
3 titanic.hist(columns = ["age", "pclass"], method = "avg", of = "survived")
```



```
1 titanic.hist(columns = ["age", "fare"], hist_type = "multi")
```



#### 8.2.4.46 info

```
1 Dataframe.info(self)
```

Summarise all the modifications made to the vDataframe.

#### Returns

The vDataframe itself.

#### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["sex"].label_encode()
  titanic["age"].fillna()
5 titanic.info()

7 #Output
  The vDataframe was modified many times:
9 * {Sat Nov 23 05:33:55 2019} [Label Encoding]: Label Encoding was applied to
    the vColumn '"sex"' using the following mapping:
    female => 0 male => 1
11 * {Sat Nov 23 05:33:55 2019} [Fillna]: 237 missing values of the vColumn '"
    age"' were filled.
```

#### 8.2.4.47 isin



```
1 vDataframe.isin(self, val: dict)
```

Verify if the elements are in the vDataframe.

### Parameters

- **val:** *<dict>*  
Dictionary of the different columns and the values to check.

### Returns

A list of booleans, result of the values checking.

### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
   titanic = load_titanic(cur)
3 #We check if there are a 15 years old and a 50 years old passengers in first
   class
   titanic.isin({"age": [15, 50], "pclass": [1, 1]})
5
   #Output
7 [ True ,  True ]
```

#### 8.2.4.48 join

```
1 vDataframe.join(
   self,
3   input_relation: str = "",
   vdf = None,
5   on: dict = {},
   how: str = 'natural')
```

Join the vDataframe with another one or another relation.

### Parameters

- **input\_relation:** *<str>*, optional  
The relation to join with the vDataframe.
- **vdf:** *<object>*, optional  
The vDataframe to join with the current vDataframe.
- **on:** *<dict>*, optional  
Dictionary of the elements which are the main keys of the joins.
- **how:** *<str>*, optional  
The join methods, it must be in {cross | natural | inner | left | right | self}

## Returns

The vDataFrame of the join.

## Example

```

from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT 0 AS id, 'Fouad' AS name) UNION ALL (SELECT 1 AS id, '
    Colin' AS name) UNION ALL (SELECT 2 AS id, 'Badr' AS name)) z"
vdf1 = vdf_from_relation(relation, dsn = "VerticaDSN")

#Output
   id    name
0    0  Fouad
1    1   Colin
2    2   Badr
Name: VDF, Number of rows: 3, Number of columns: 2

relation = "((SELECT 0 AS id, 'Apple' AS fav_fruit) UNION ALL (SELECT 1 AS id,
    'Blueberries' AS fav_fruit) UNION ALL (SELECT 2 AS id, 'Mango' AS
    fav_fruit)) z"
vdf2 = vdf_from_relation(relation, dsn = "VerticaDSN")

#Output
   id    fav_fruit
0    0      Apple
1    1 Blueberries
2    2      Mango
Name: VDF, Number of rows: 3, Number of columns: 2

vdf1.join(vdf = vdf2)

#Output
   id    name    fav_fruit
0    0  Fouad      Apple
1    1   Colin Blueberries
2    2   Badr      Mango
Name: VDF, Number of rows: 3, Number of columns: 3

```

### 8.2.4.49 kurtosis / kurt

```

vDataFrame.kurtosis(self, columns: list = [])

```

Aggregate the different columns by computing the unbiased kurtosis using Fisher's definition (kurtosis of normal = 0.0).

## Parameters

- **columns:** *<list>*, optional  
List of the vDataframe Columns. If this parameter is empty, the method will consider all the numerical columns.

### Returns

The `tablesamle` type containing the kurtosis (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.kurt()

5 #Output
                                kurtosis
7 "age"                        0.15689691331997
  "body"                       -1.23864914040606
9  "survived"                  -1.68576262213743
  "pclass"                    -1.34962169484619
11 "parch"                     22.6438022640172
   "fare"                      26.2543152552867
13 "sibsp"                     19.2138853382802

```

#### 8.2.4.50 last

```

1 vDataframe.last(self, ts: str, offset: str)

```

Keep only the last events of the specific time series.

### Parameters

- **ts:** *<str>*  
The time series column.
- **offset:** *<str>*  
The offset time interval used to filter the data.

### Returns

The vDataframe itself.

### Example

```

1 from vertica_ml_python.learn.datasets import load_smart_meters
  sm = load_smart_meters(cur)
3 sm.last(ts = "time", offset = "1 day")

```

```

5 #Output
      time      val      id
7 0    2015-09-10 05:00:00  0.0930000    1
  1    2015-09-10 05:30:00  0.1410000    1
9 2    2015-09-10 06:45:00  0.6030000    2
  3    2015-09-10 07:15:00  0.8480000    3
11 4    2015-09-10 07:30:00  0.0570000    6
    ...      ...      ...      ...
13 Name: smart_meters, Number of rows: 20, Number of columns: 3

15 # We only keep the last day of the dataset

```

#### 8.2.4.51 load

```
1 vDataframe.load(self, offset: int = -1)
```

Load the vDataframe corresponding to the selected saving.

#### Parameters

- **offset:** <list>, optional  
The saving position (-1 for the last one)

#### Returns

Create a new vDataframe which is based on the selected saving.

#### Examples

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.save()
  titanic["sex"]
5
6 #Output
7      sex
0    female
9    male
  2    female
11   male
  4    male
13   ...   ...
14 Name: sex, Number of rows: 1234, dtype: varchar(20)
15
16 titanic["sex"].label_encode()

```

```

17 titanic["sex"]
19 #Output
    sex
21 0    0
    1    1
23 2    0
    3    1
25 4    1
    ... ..
27 Name: sex, Number of rows: 1234, dtype: int

29 titanic = titanic.load()
    titanic["sex"]
31 #Output
    sex
33 0    female
35 1    male
    2    female
37 3    male
    4    male
39 ... ..
    Name: sex, Number of rows: 1234, dtype: varchar(20)

```

#### 8.2.4.52 mad

```
vDataframe.mad(self, columns: list = [])
```

Aggregate the different columns by computing the mean absolute deviation of each one.

#### Parameters

- **columns:** *<list>*, optional  
List of the vDataframe columns. If this parameter is empty, the method will consider all the numerical columns.

#### Returns

The `tablesample` type containing the mad (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.mad()

```

```

5 #Output
                                     mad
7 "age"                11.254785419447906
8 "body"               82.97457627118644
9 "survived"          0.46337036268450094
10 "pclass"            0.7689071656916803
11 "parch"             0.5820801231451393
12 "fare"              30.625865942462237
13 "sibsp"             0.6829616826333305

```

#### 8.2.4.53 max

```

1 vDataframe.max(self, columns: list = [])

```

Aggregate the different columns by computing the max of each one.

#### Parameters

- **columns:** *<list>*, optional  
List of the vDataframe columns. If this parameter is empty, the method will consider all the numerical columns.

#### Returns

The `tablesample` type containing the max (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
3 titanic.max()

5 #Output
                                     max
7 "age"                80.0
8 "body"              328.0
9 "survived"           1.0
10 "pclass"            3.0
11 "parch"             9.0
12 "fare"             512.3292
13 "sibsp"             8.0

```

#### 8.2.4.54 median

```
1 vDataframe.median(self, columns: list = [])
```

Aggregate the different columns by computing the median of each one.

##### Parameters

- **columns:** *<list>*, optional  
List of the vDataframe columns. If this parameter is empty, the method will consider all the numerical columns.

##### Returns

The `tablesampl` type containing the medians (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

##### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
   titanic = load_titanic(cur)
3 titanic.median()

5 #Output
   median
7 "age"      28.0
   "body"    160.5
9 "survived"  0.0
   "pclass"  3.0
11 "parch"    0.0
   "fare"    14.4542
13 "sibsp"    0.0
```

#### 8.2.4.55 memory\_usage

```
1 vDataframe.memory_usage(self)
```

Memory usage of the object in byte (it will never exceed some kb).

##### Returns

The `tablesampl` type containing the memory usage of each column (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

##### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.memory_usage(unit = 'kb')

5 #Output
      value
7 object      687
  "age"       182
9  "body"      183
  "survived"   187
11 "ticket"    185
  "home.dest"  188
13 "cabin"     184
  "sex"        182
15 "pclass"    185
  "embarked"   187
17 "parch"     184
  "fare"       183
19 "name"      183
  "boat"       183
21 "sibsp"     184
  total       3267

```

8.2.4.56 min

```
vDataframe.max(self, columns: list = [])
```

Aggregate the different columns by computing the min of each one.

### Parameters

- **columns:** *<list>*, optional  
List of the vDataframe columns. If this parameter is empty, the method will consider all the numerical columns.

### Returns

The `tablesample` type containing the min (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.min()

```



```

5 #Output
6
7         min
8 "age"      0.33
9 "body"      1.0
10 "survived"  0.0
11 "pclass"    1.0
12 "parch"     0.0
13 "fare"      0.0
14 "sibsp"     0.0

```

#### 8.2.4.57 nlargest

```
1 vDataframe.nlargest(self, column: str, n: int = 10)
```

Returns the n largest elements of the vDataframe sorting by a specific column.

#### Parameters

- **column:** <str>  
The column used to sort the data.
- **n:** <int>, optional  
The number of elements to consider.

#### Returns

The `tablesampler` type containing the vDataframe n largest elements (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
3 titanic.nlargest(column = "fare")
4
5 #Output
6
7      age      body      survived      ticket
8 0   36.000   None           1    PC 17755
9 1   58.000   None           1    PC 17755
10 2   35.000   None           1    PC 17755
11
12      cabin      sex      pclass      embarked      parch      fare      \
13 0   B51 B53 B55    male           1           C           1   512.32920  \
14 1   B51 B53 B55  female           1           C           1   512.32920  \
15 2           B101    male           1           C           0   512.32920  \
16
17      name      boat      sibsp
18 0  Cardeza, Mr. Thomas Drake Martinez      3      0
19 1  Cardeza, Mrs. James Warburton Martine...      3      0

```

```

17 2          Lesurer, Mr. Gustave J          3          0
    Name: nlargest, Number of rows: 3, Number of columns: 14

```

#### 8.2.4.58 normalize

```
vDataframe.normalize(self, method = "zscore")
```

Normalize all the numerical columns of the vDataframe using the corresponding method. Use the `normalize` method of each column for more flexibility.

##### Parameters

- **method:** <str>, optional  
The method to be used: {zscore | robust\_zscore | minmax}

##### Returns

The vDataframe itself.

##### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.normalize()
  titanic["fare"]
5
7 #Output
  fare
0      2.2335228377568673306163744003
9 1      2.2335228377568673306163744003
  2      2.2335228377568673306163744003
11 3     -0.6451344183800711827483251581
  4      0.2951864297839290254556257484
13 ...
    Name: fare, Number of rows: 1234, dtype: float

```

#### 8.2.4.59 nsmaallest

```
vDataframe.nsmallest(self, column: str, n: int = 10)
```

Returns the n smallest elements of the vDataframe sorting by a specific column.

##### Parameters

- **column:** `<str>`  
The column used to sort the data.
- **n:** `<int>`, optional  
The number of elements to consider.

## Returns

The `tablesamples` type containing the `vDataFrame` `n` smallest elements (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to `vDataFrame` using the `to_vdf` method.

## Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.nsmallest(column = "fare")

5 #Output
   age  body  survived  ticket
7 0  39.000  None      0   112050
  1   None  None      0   112051
  2   None  None      0   112058
   cabin  sex  pclass  embarked  parch  fare  \
11 0   A36  male      1         S      0  0.00000  \
  1   None  male      1         S      0  0.00000  \
13 2   B102  male      1         S      0  0.00000  \
   name  boat  sibsp
15 0  Andrews, Mr. Thomas Jr  None      0
  1  Chisholm, Mr. Roderick Robert Crispin  None      0
17 2  Fry, Mr. Richard  None      0
Name: nsmallest, Number of rows: 3, Number of columns: 14
```

### 8.2.4.60 numcol

```
vDataFrame.numcol(self)
```

Returns the `vDataFrame` numerical columns.

## Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.numcol()

5 #Output
["age", "body", "survived", "pclass", "parch", "fare", "sibsp"]
```

### 8.2.4.61 pivot\_table

```

vDataframe.pivot_table(
    self,
    columns: list,
    method: str = "count",
    of: str = "",
    h: tuple = (None, None),
    max_cardinality: tuple = (20, 20),
    show: bool = True,
    cmap: str = '',
    limit_distinct_elements: int = 1000,
    with_numbers: bool = True)

```

Draw the corresponding pivot table.

#### Parameters

- **columns:** *<list>*  
The two columns used to build the pivot table.
- **method:** *<str>*, optional  
count | density | avg | min | max | sum  
count (default): count is used as aggregation  
density: density is used as aggregation  
avg | min | max | sum: these aggregations are used only if "of" is informed.
- **of:** *<str>*, optional  
The column used to compute the aggregation. This variable is used only if "method" in {avg | min | max | sum}
- **max\_cardinality:** *<tuple>*, optional  
The maximum cardinality of each column. Under this number the column is automatically considered as categorical.
- **h:** *<tuple>*, optional  
The interval size of each column. It is used if the column is numerical. In the other case, if h is not informed. The best "h" will be computed automatically. If the column is a date, h represents the interval size in seconds.
- **cmap:** *<str>*, optional  
Color Maps
- **limit\_distinct\_elements:** *<int>*, optional  
The maximum number of distinct elements. The other categories will be ignored.
- **show:** *<bool>*, optional  
Draw the pivot table using matplotlib.
- **with\_numbers:** *<bool>*, optional  
If False, draw the pivot table without displaying the numbers.

#### Returns

The `tablesample` type containing the pivot table (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to `vDataframe` using the `to_vdf` method.

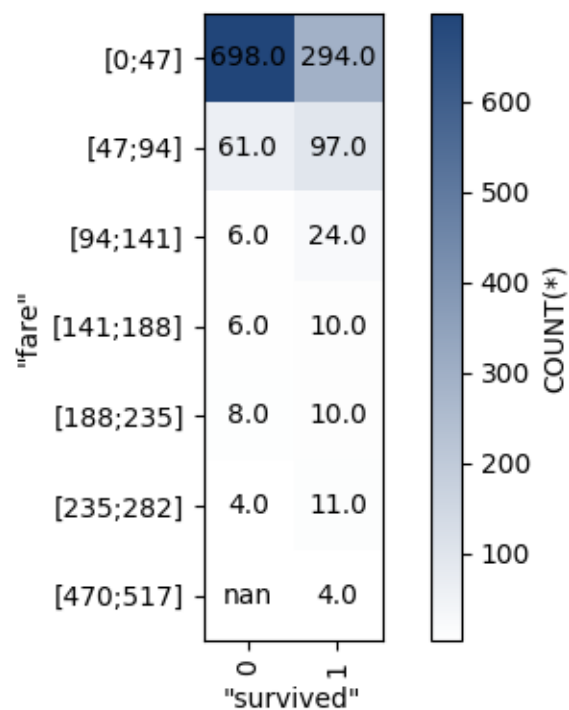
## Example

```

1 titanic.pivot_table(columns = ["fare", "survived"])
3
3 #Output
   "fare"/"survived"    0    1
5 0      [0;47]      698   294
1 1      [47;94]      61    97
7 2      [94;141]      6    24
3 3     [141;188]      6    10
9 4     [188;235]      8    10
5 5     [235;282]      4    11
11 6     [470;517]      4     4

```

Pivot Table of "fare" vs "survived"



### 8.2.4.62 plot

```

1 vDataframe.plot(
   self,
3   ts: str,

```

```
5         columns: list = [],  
           start_date: str = "",  
           end_date: str = "")
```

Plot the time series selected columns.

### Parameters

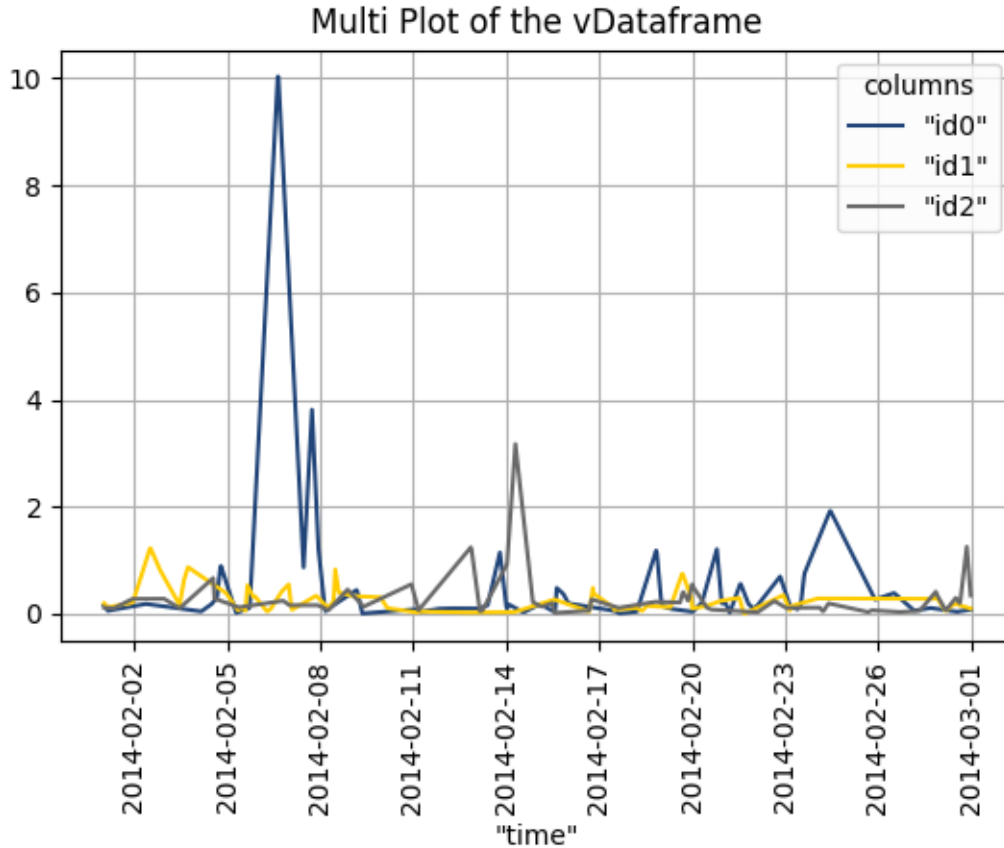
- **ts:** <str>  
The time series used to plot the different elements.
- **columns:** <list>, optional  
The columns to plot. If empty, all the numerical columns will be plotted.
- **start\_date:** <str>, optional  
Start Date.
- **end\_date:** <str>, optional  
End Date.

### Returns

The vDataframe itself.

### Example

```
1 from vertica_ml_python.learn.datasets import load_smart_meters  
2 sm = load_smart_meters(cur)  
   # Slicing and interpolating the time series  
4 sm = sm.asfreq(ts = "time", rule = "30 minutes", method = {"val": "linear"},  
   by = ["id"])  
   # Building the features corresponding to the consumption of 3 different homes  
6 sm.eval("id0", "DECODE(id, 0, val, NULL)")  
   sm.eval("id1", "DECODE(id, 1, val, NULL)")  
8 sm.eval("id2", "DECODE(id, 2, val, NULL)")  
   # Drawing the time series  
10 sm.plot(ts = "time", columns = ["id0", "id1", "id2"], start_date = "2014-02-01  
   00:00:00", end_date = "2014-03-01 00:00:00")
```



#### 8.2.4.63 product / prod

```
vDataframe.product(self, columns: list = [])
```

Aggregate the different columns by computing the product of each one.

##### Parameters

- **columns:** *<list>*, optional  
List of the vDataframe Columns. If this parameter is empty, the method will consider all the numerical columns.

##### Returns

The `tablesampl` type containing the products (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

##### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
3 titanic.prod()
```

```

5 #Output
                                     prod
7 "age"                               inf
  "body"          5.04839415885224e+245
9 "survived"          0.0
  "pclass"           inf
11 "parch"            0.0
   "fare"            0.0
13 "sibsp"            0.0

```

#### 8.2.4.64 quantile

```

1 vDataframe.quantile(self, q: list, columns: list = [])

```

Aggregate the different columns by computing the different selected quantiles of each one.

#### Parameters

- **q:** *<list>*  
List of the different quantiles (each element must be in [0,1]).
- **columns:** *<list>*, optional  
List of the vDataframe Columns. If this parameter is empty, the method will consider all the numerical columns.

#### Returns

The `tablesampl` type containing the quantiles (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.quantile(q = [0.1, 0.5, 0.9])

5 #Output
          10.0%      50.0%      90.0%
7 "age"         14.5       28.0       50.0
  "body"        37.7      160.5      297.3
9 "survived"      0.0        0.0        1.0
  "pclass"        1.0        3.0        3.0
11 "parch"        0.0        0.0        1.0
   "fare"         7.5892    14.4542     79.13
13 "sibsp"        0.0        0.0        1.0

```



### 8.2.4.65 rank

```
1 vDataframe.rank(self, order_by: list, method: str = "first", by: list = [],
   name = "")
```

Compute the rank of the selected column. This method will add the new feature to the vDataframe.

#### Parameters

- **order\_by:** <list>  
The columns used to order the vDataframe elements.
- **method:** <str>, optional  
Method used to compute the Rank, it must be in {first | dense | percent}
- **by:** <list>, optional  
The columns used to group the vDataframe elements.
- **name:** <str>, optional  
Name of the new feature.

#### Returns

The vDataframe itself.

#### Example

```
1 from vertica_ml_python.learn.datasets import load_smart_meters
   sm = load_smart_meters(cur)
3 sm.rank(order_by = ["time"], by = ["id"])

5 #Output
   time          val    id  first_rank_time_by_id
7 0    2014-01-01 11:00:00  0.0290000    0          1
  1    2014-01-01 13:45:00  0.2770000    0          2
9 2    2014-01-02 10:45:00  0.3210000    0          3
  3    2014-01-02 11:15:00  0.3050000    0          4
11 4    2014-01-02 13:45:00  0.3580000    0          5
   ...          ...          ...          ...          ...
13 Name: smart_meters, Number of rows: 11844, Number of columns: 4
```

### 8.2.4.66 rolling

```
1 vDataframe.rolling(
   self,
3   name: str,
   aggr: str,
```

```

5         column: str,
           preceding,
7         following,
           expr: str = "",
9         by: list = [],
           order_by: list = [],
11        method: str = "rows")

```

Compute a Moving Window. The method will add the new feature to the vDataframe.

### Parameters

- **name:** <str>  
Name of the new feature.
- **aggr:** <str>  
Aggregation used to compute the Moving Window.
- **column:** <str>  
The column used to compute the aggregation.
- **preceding:** <str>,  
Rule for the preceding elements. It can be an integer if the method is set to 'rows' otherwise an interval. It can also be set to 'unbounded' in order to consider all the elements before the event.
- **following:** <str>,  
Rule for the following elements. It can be an integer if the method is set to 'rows' otherwise an interval. It can also be set to 'unbounded' in order to consider all the elements after the event.
- **expr:** <str>, optional  
The expression to consider instead of the aggregation. It can be used if a complex Moving Window is needed.
- **by:** <list>, optional  
The columns used to group the vDataframe elements.
- **order\_by:** <list>, optional  
The columns used to order the vDataframe elements. If it is empty, the vDataframe will be ordered by the selected column.
- **method:** <list>, optional  
Method used to compute the Moving Window, it must be in {rows | range} (range is only available if the order\_by column is a timestamp)

### Returns

The vDataframe itself.

### Example

```

1 from vertica_ml_python.learn.datasets import load_smart_meters
  sm = load_smart_meters(cur)
3 # Computing the highest consumption per home one day preceding and one day
   following the current date

```

```

sm.rolling(
    name = "highest_consumption_1p_1f",
    aggr = "max", column = "val",
    preceding = "1 days",
    following = "1 days",
    by = ["id"],
    order_by = ["time"],
    method = "range")

```

#Output

		time	val	id	val_cummax
		time	val	id	highest_consumption_1p_1f
0	2014-01-01 11:00:00	0.0290000	0	0.3210000	
1	2014-01-01 13:45:00	0.2770000	0	0.3580000	
2	2014-01-02 10:45:00	0.3210000	0	0.3580000	
3	2014-01-02 11:15:00	0.3050000	0	0.3580000	
4	2014-01-02 13:45:00	0.3580000	0	0.3580000	
...	...	...	...	...	

Name: smart\_meters, Number of rows: 11844, Number of columns: 4

#### 8.2.4.67 sample

```
vDataframe.sample(self, x: float)
```

Returns a sample of the vDataframe relation.

##### Parameters

- **x:** <float>  
A float which indicate the sample value (must be in [0,1]).

##### Returns

The `tablesample` type containing the sample (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

##### Example

```

from vertica_ml_python.learn.datasets import load_titanic
titanic = load_titanic(cur)
titanic.sample(x = 0.005)

```

#Output

	cabin	sex	pclass	embarked	parch	\\
0	C6	male	1	C	0	\\
1	None	male	2	S	0	\\

2	None	male	2	S	0	\\
3	F2	male	2	S	1	\\
4	None	male	3	Q	0	\\
5	None	female	3	Q	0	\\
6	None	female	3	C	1	\\
	fare			name	boat	sibsp
0	75.24170			Beattie, Mr. Thomson	A	0
1	13.00000			Greenberg, Mr. Samuel	None	0
2	10.50000			Wheadon, Mr. Edward H	None	0
3	26.00000			Navratil, Master. Michel M	D	1
4	7.73330			O Connell, Mr. Patrick D	None	0
5	7.73330			Smyth, Miss. Julia	13	0
6	15.24580			Touma, Miss. Maria Youssef	C	1

Name: Sample(0.005) of titanic, Number of rows: 7, Number of columns: 14

#### 8.2.4.68 save

```
vDataframe.save(self)
```

Save the vDataframe current disposition. In case of unwanted operations, it will be possible to go back by loading a saving using the `load` method.

#### Returns

The vDataframe itself.

#### Examples

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.save()
  titanic["sex"]
5
  #Output
7      sex
0    female
9      male
2    female
11     male
4      male
13 ...    ...
  Name: sex, Number of rows: 1234, dtype: varchar(20)
15
  titanic["sex"].label_encode()
17 titanic["sex"]

```

```

19 #Output
      sex
21 0      0
21 1      1
23 2      0
23 3      1
25 4      1
... ..
27 Name: sex, Number of rows: 1234, dtype: int

29 titanic = titanic.load()
titanic["sex"]
31
31 #Output
      sex
33 0    female
35 1     male
35 2    female
37 3     male
37 4     male
39 ... ..
39 Name: sex, Number of rows: 1234, dtype: varchar(20)

```

#### 8.2.4.69 scatter

```

vDataframe.scatter(
2     self,
      columns: list,
4     cat_col: str = "",
      max_cardinality: int = 3,
6     cat_priority: list = [],
      with_others: bool = True,
8     max_nb_points: int = 20000)

```

Draw the scatter plot of the input columns.

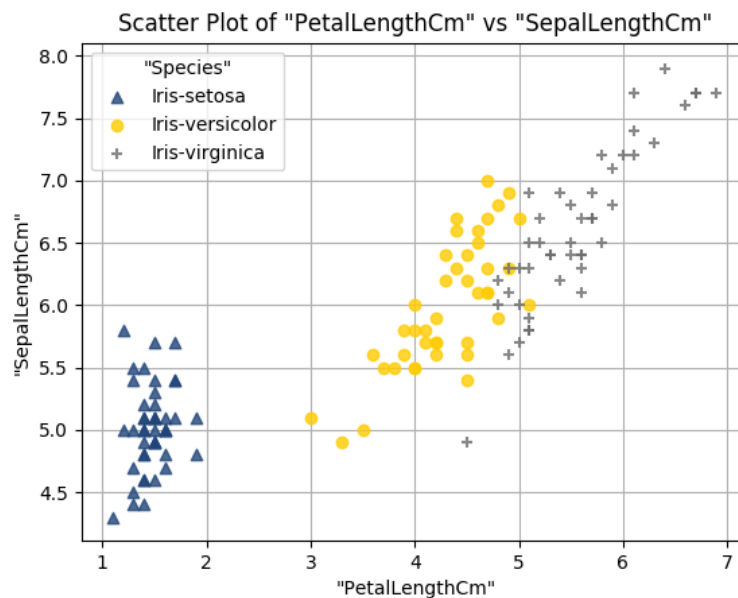
#### Parameters

- **columns:** *<str>*  
The two or three columns used to draw the scatter plot.
- **catcol:** *<str>*, optional  
The categorical column used as label.
- **max\_cardinality:** *<int>*, optional  
The maximum cardinality of the categorical column, all the other categories are merged to create the "others" category.

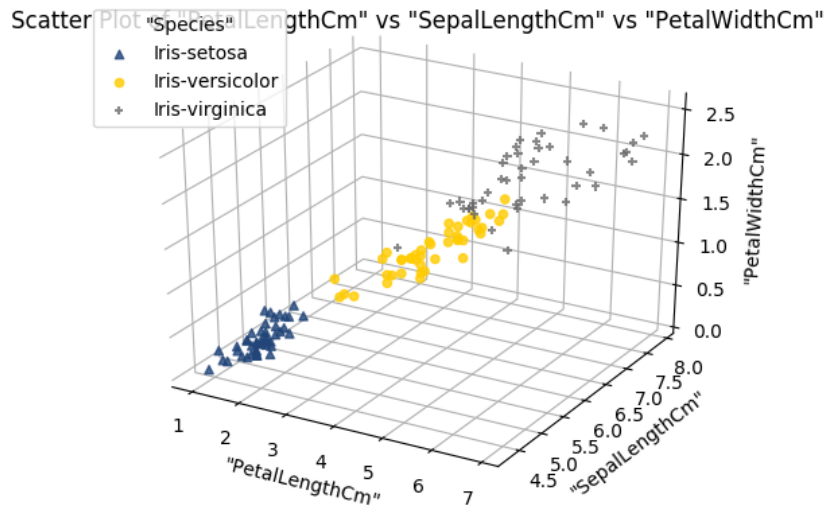
- **cat\_priority:** *<list>*, optional  
The list of the categories took into account during the computation.
- **with\_others:** *<bool>*, optional  
Include the "others" category.
- **max\_nb\_points:** *<int>*, optional  
The maximum number of points in the scatter plot. The points are taken randomly from the table.

## Examples

```
from vertica_ml_python.learn.datasets import load_iris
iris = load_iris(cur)
iris.scatter(columns = ["PetalLengthCm", "SepalLengthCm"], catcol = "Species")
```



```
iris.scatter(columns = ["PetalLengthCm", "SepalLengthCm", "PetalWidthCm"],
             catcol = "Species")
```



#### 8.2.4.70 scatter\_matrix

```
vDataframe.scatter(self, columns: list = [])
```

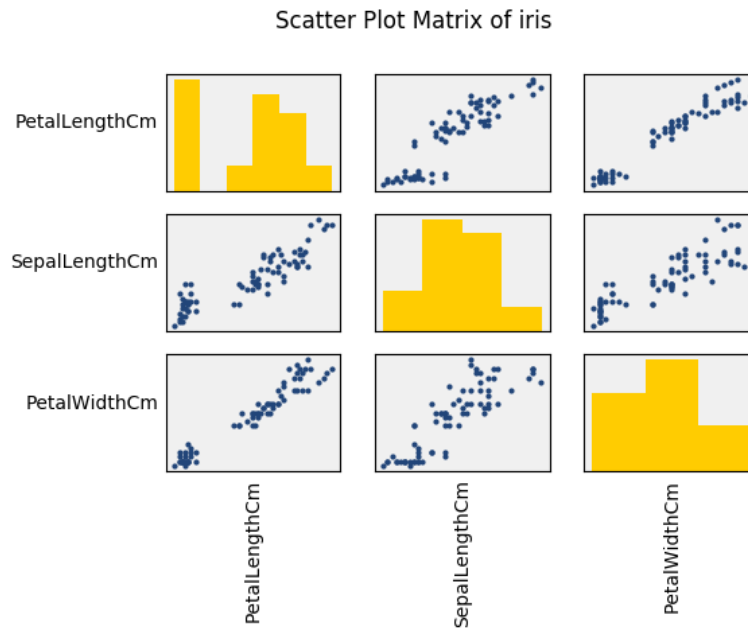
Draw the scatter matrix of the input columns.

#### Parameters

- **columns:** *<str>*  
List of the vDataframe columns. If this parameter is empty, the method will consider all the numerical columns.

#### Examples

```
1 from vertica_ml_python.learn.datasets import load_iris
  iris = load_iris(cur)
3 iris.scatter_matrix(columns = ["PetalLengthCm", "SepalLengthCm", "PetalWidthCm"
  " ])
```



#### 8.2.4.71 select

```
1 vDataframe.select(self, columns: list)
```

Select some of the vDataframe columns.

#### Parameters

- **columns:** *<list>*  
List of the columns to select.

#### Returns

A new vDataframe containing only the selected columns.

#### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
   titanic = load_titanic(cur)
3 titanic.select(columns = ['pclass', 'age'])

5 #Output
   age    pclass
7 0    2.000      1
   1    30.000      1
9 2    25.000      1
   3    39.000      1
11 4    71.000      1
```



```

...      ...      ...
13 Name: titanic, Number of rows: 1234, Number of columns: 2

```

#### 8.2.4.72 sem

```

1 vDataframe.sem(self, columns: list = [])

```

Aggregate the different columns by computing the unbiased standard error of the mean of each element.

##### Parameters

- **columns:** *<list>*, optional  
List of the vDataframe columns. If this parameter is empty, the method will consider all the numerical columns.

##### Returns

The `tablesampl` type containing the sem (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

##### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.sem()

5 #Output
                                sem
7 "age"                0.457170684605937
  "body"               8.89054334053935
9 "survived"          0.0137077946622731
  "pclass"             0.023983078299543
11 "parch"            0.0247266111413956
   "fare"              1.49928585339507
13 "sibsp"            0.029637534446613

```

#### 8.2.4.73 sessionize

```

1 vDataframe.sessionize(
    self,
3     ts: str,
    by: list = [],
5     session_threshold = "30 minutes",
    name = "session_id")

```

Create a new feature which will represent the different elements session. A session is defined as a user inactivity during a certain amount of time (called the session threshold).

### Parameters

- **ts:** <str>  
The vDataframe time series.
- **by:** <list>  
List of the different element used to group the vDataframe (Most of the time it is a user id).
- **session\_threshold:** <str>, optional  
The session threshold. It must be a time interval.
- **name:** <str>, optional  
Name of the session.

### Returns

The vDataframe itself.

### Example

```
from vertica_ml_python.vdataframe import vdf_from_relation
2 relation = "(SELECT '2013-01-24 07:06:46'::timestamp AS date_time, 0 AS id)
    UNION ALL (SELECT '2013-01-24 07:07:10'::timestamp AS date_time, 0 AS id)
    UNION ALL (SELECT '2013-01-24 07:08:11'::timestamp AS date_time, 0 AS id)
    UNION ALL (SELECT '2013-01-24 09:01:41'::timestamp AS date_time, 0 AS id)
    UNION ALL (SELECT '2013-01-24 09:10:11'::timestamp AS date_time, 0 AS id))
    z"
vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
4
#Output
6           date_time      id
0  2013-01-24 07:06:46      0
8  2013-01-24 07:07:10      0
2  2013-01-24 07:08:11      0
10 2013-01-24 09:01:41      0
4  2013-01-24 09:10:11      0
12 Name: VDF, Number of rows: 5, Number of columns: 2

14 vdf.sessionize(ts = "date_time", by = ["id"])

16 #Output
           date_time      id  session_id
18 0  2013-01-24 07:06:46      0          0
    1  2013-01-24 07:07:10      0          0
    2  2013-01-24 07:08:11      0          0
    3  2013-01-24 09:01:41      0          1
    4  2013-01-24 09:10:11      0          1
22
```

```
Name: VDF, Number of rows: 5, Number of columns: 3
```

#### 8.2.4.74 set\_cursor

```
1 vDataframe.set_cursor(self, cursor)
```

Replace the current cursor with a new one.

- **cursor:** *<object>*  
A Database cursor.

#### Returns

The vDataframe itself.

#### 8.2.4.75 set\_dsn

```
1 vDataframe.set_dsn(self, dsn: str)
```

Replace the current DSN with a new one.

- **dsn:** *<str>*  
Vertica DSN.

#### Returns

The vDataframe itself.

#### 8.2.4.76 shape

```
1 vDataframe.shape(self)
```

Returns the vDataframe shape (Number of rows and columns).

#### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
3 titanic.shape()

5 #Output
(1234, 14)
```

#### 8.2.4.77 skewness / skew

```
vDataframe.skewness(self, columns: list = [])
```

Aggregate the different columns by computing the unbiased skewness of each one.

##### Parameters

- **columns:** *<list>*, optional  
List of the vDataframe columns. If this parameter is empty, the method will consider all the numerical columns.

##### Returns

The `tablesample` type containing the skewness (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

##### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.skew()

5 #Output
                                skewness
7 "age"                0.408876460779437
  "body"               0.0617701251569532
9  "survived"          0.56300284427369
  "pclass"            -0.576258567091907
11 "parch"             3.79801928269975
   "fare"              4.30069918891405
13 "sibsp"             3.7597831472411
```

#### 8.2.4.78 sort

```
1 vDataframe.sort(self, columns: list = [])
```

Sort the vDataframe using specific columns.

##### Parameters

- **columns:** *<list>*, optional  
The columns used to sort the data.

##### Returns

The vDataframe itself.

##### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.sort(["fare"])

5 #Output
   fare                                name    boat    sibsp
7 0      None                        Storey, Mr. Thomas    None    0
  1    0.00000    Chisholm, Mr. Roderick Robert Crispin    None    0
9 2    0.00000                        Andrews, Mr. Thomas Jr    None    0
  3    0.00000                                Fry, Mr. Richard    None    0
11 4    0.00000                        Harrison, Mr. William    None    0
   ...      ...                                ...    ...    ...
13 Name: titanic, Number of rows: 1234, Number of columns: 14

```

#### 8.2.4.79 sql\_on\_off

```

1 vDataframe.sql_on_off(self)

```

Prints all the sql queries used by the vDataframe for the different computations. If it is already enable, it will turn it off.

#### Returns

The vDataframe itself.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.sql_on_off()
  titanic.max()

5 #Output
7 $ COMPUTE AGGREGATION(S) $

9 SELECT MAX("age"),
        MAX("body"),
11        MAX("survived"),
        MAX("pclass"),
13        MAX("parch"),
        MAX("fare"),
15        MAX("sibsp")
FROM
17 (SELECT "age" AS "age",
        "body" AS "body",
19        "survived" AS "survived",

```

```

21     "ticket" AS "ticket",
    "home.dest" AS "home.dest",
23     "cabin" AS "cabin",
    "sex" AS "sex",
25     "pclass" AS "pclass",
    "embarked" AS "embarked",
    "parch" AS "parch",
27     "fare" AS "fare",
    "name" AS "name",
29     "boat" AS "boat",
    "sibsp" AS "sibsp"
31 FROM public.titanic) final_table

```

#### 8.2.4.80 statistics

```
vDataframe.statistics(self, columns: list = [], skew_kurt_only: bool = False)
```

Summarise the vDataframe with statistical information.

#### Parameters

- **columns:** *<list>*, optional  
The columns used to compute the mathematical information. If this parameter is empty, the method will consider all the vDataframe numerical columns.
- **skew\_kurt\_only:** *<bool>*, optional  
Only compute the skewness and kurtosis.

#### Returns

The `tablesample` type containing the statistical information (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.statistics(columns = ["age", "fare", "pclass"])

#Output

```

	"age"	"fare"	"pclass"
count	997.0	1233.0	1234.0
avg	30.1524573721163	33.9637936739659	2.28444084278768
stddev	14.4353046299159	52.6460729831293	0.842485636190292
min	0.33	0.0	1.0

11	10%	14.5	7.5892	1.0
	25%	21.0	7.8958	1.0
13	median	28.0	14.4542	3.0
	75%	39.0	31.3875	3.0
15	90%	50.0	79.13	3.0
	max	80.0	512.3292	3.0
17	skewness	0.408876460779437	4.30069918891405	-0.576258567091907
	kurtosis	0.15689691331997	26.2543152552867	-1.34962169484619

#### 8.2.4.81 std

```
vDataframe.std(self, columns: list = [])
```

Aggregate the different columns by computing the standard deviation of each one.

##### Parameters

- **columns:** *<list>*, optional  
List of the vDataframe Columns. If this parameter is empty, the method will consider all the numerical columns.

##### Returns

The `tablesampl` type containing the std (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

##### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.std()

5 #Output
                                stddev
7 "age"                        14.4353046299159
  "body"                       96.5760207557808
9 "survived"                   0.481532018641288
  "pclass"                     0.842485636190292
11 "parch"                     0.868604707790392
   "fare"                       52.6460729831293
13 "sibsp"                      1.04111727241629
```

#### 8.2.4.82 sum

```
1 vDataframe.sum(self, columns: list = [])
```

Aggregate the different columns by computing the sum of each one.

### Parameters

- **columns:** *<list>*, optional  
List of the vDataframe columns. If this parameter is empty, the method will consider all the numerical columns.

### Returns

The `tablesample` type containing the sums (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method

### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.sum()

5 #Output
                                sum
7 "age"                        30062.0
  "body"                       19369.0
9 "survived"                   450.0
  "pclass"                     2819.0
11 "parch"                     467.0
   "fare"                      41877.3576
13 "sibsp"                      622.0

```

#### 8.2.4.83 tail

```

1 vDataframe.tail(self, limit: int = 5, offset: int = 0)

```

Returns a part of the vDataframe. The tail is not necessary the end of the object.

### Parameters

- **limit:** *<int>*, optional  
The number of elements to return.
- **offset:** *<int>*, optional  
The number of elements to skip.

### Returns

The `tablesample` type containing the tail of the vDataframe (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

### Example



```

1 from vertica_ml_python.learn.datasets import load_smart_meters
  sm = load_smart_meters(cur)
3 sm.tail(limit = 10, offset = 1000)

5 #Output
      time           val      id
7 1000  2014-02-22 16:00:00  0.1250000  9
  1001  2014-02-22 16:30:00  0.8130000  5
9 1002  2014-02-22 18:00:00  0.3360000  3
  1003  2014-02-22 19:30:00  0.3020000  5
11 1004  2014-02-22 20:00:00  0.6970000  0
  1005  2014-02-22 21:45:00  0.2960000  8
13 1006  2014-02-22 21:45:00  0.3090000  9
  1007  2014-02-22 22:00:00  0.3390000  4
15 1008  2014-02-22 22:30:00  0.3500000  1
  1009  2014-02-22 23:15:00  0.5830000  8
17 ...           ...           ...
Name: smart_meters, Number of rows: 11844, Number of columns: 3

```

#### 8.2.4.84 time\_on\_off

```
vDataframe.time_on_off(self)
```

Prints all the vDataframe queries elapsed time. If it is already enable, it will turn it off.

#### Returns

The vDataframe itself.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.time_on_off()
  titanic.max()

5 #Output
7 Elapsed Time: 0.009672880172729492
  -----

```

#### 8.2.4.85 to\_csv

```
vDataframe.to_csv(  
    self,  
    name: str,  
    path: str = '',  
    sep: str = ',',  
    na_rep: str = '',  
    quotechar: str = '"',  
    usecols: list = [],  
    header: bool = True,  
    new_header: list = [],  
    order_by: list = [],  
    nb_row_per_work: int = 0)
```

Create a csv file from the vDataframe relation.

### Parameters

- **name:** <str>  
File Name.
- **path:** <str>, optional  
File Path.
- **sep:** <str>, optional  
Elements separator.
- **na\_rep:** <str>, optional  
How to represent missing values.
- **quotechar:** <str>, optional  
How to enclose the varchar.
- **usecols:** <list>, optional  
Columns to use to write the csv file. If it is empty, all the vDataframe columns will be used.
- **header:** <bool>, optional  
Write the header.
- **new\_header:** <list>, optional  
Replace the default header by a new one.
- **order\_by:** <list>, optional  
Order the elements using specific columns before writing.
- **nb\_row\_per\_work:** <int>, optional  
Number of rows to be read during each process of the loop. This parameter can lead to a partially wrong csv files if the data are not sorted correctly. Leave it to 0 to read the entire file on one time.

### Returns

The vDataframe itself.

#### 8.2.4.86 to\_db

```

vDataframe.to_db(
    self
    name: str,
    usecols: list = [],
    relation_type: str = "view")

```

Save the vDataframe relation in the Database. The vDataframe will be then recreated from scratch using the new relation.

#### Parameters

- **name:** <str>  
Name of the new relation.
- **usecols:** <list>, optional  
List of the vDataframe columns to use.
- **relation\_type:** <str>, optional  
The relation type. This parameter can be a 'view' or a 'table'.

#### Returns

The vDataframe itself.

#### 8.2.4.87 to\_pandas

```

vDataframe.to_pandas(self)

```

Convert the vDataframe to a pandas.DataFrame. Be careful, if the volume is huge it can break down the system.

#### Returns

The pandas.DataFrame of the vDataframe.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
3 titanic.to_pandas()

5 #Output
6
7      age   body  survived   ticket  home.dest \
1  0  2.000   NaN         0   113781  Montreal, PQ / Chesterville, ON
2  1 30.000 135.0         0   113781  Montreal, PQ / Chesterville, ON
3  2 25.000   NaN         0   113781  Montreal, PQ / Chesterville, ON
4  3 39.000   NaN         0   112050      Belfast, NI
5  4 71.000  22.0         0   PC 17609  Montevideo, Uruguay

```

```

13      cabin      sex  pclass embarked  parch      fare  \
0   C22 C26   female      1          S      2  151.55000
15  1   C22 C26    male      1          S      2  151.55000
2   C22 C26   female      1          S      2  151.55000
17  3      A36    male      1          S      0   0.00000
4      None    male      1          C      0  49.50420
19
                                         name  boat  sibsp
21  0                               Allison, Miss. Helen Loraine  None    1
22  1                               Allison, Mr. Hudson Joshua Creighton  None    1
23  2  Allison, Mrs. Hudson J C (Bessie Waldo Daniels)  None    1
24  3                               Andrews, Mr. Thomas Jr  None    0
25  4                               Artagaveytia, Mr. Ramon  None    0
[1234 rows x 14 columns]

```

#### 8.2.4.88 to\_vdf

```
vDataframe.to_vdf(self, name: str)
```

Save the vDataframe to the vdf format. You can use `read_vdf` to read this file type and load the vDataframe.

##### Parameters

- **name:** <str>  
Name of the vdf file

##### Returns

The vDataframe itself.

#### 8.2.4.89 var

```
vDataframe.var(self, columns: list = [])
```

Aggregate the different columns by computing the variance of each one.

##### Parameters

- **columns:** <list>, optional  
List of the vDataframe columns. If this parameter is empty, the method will consider all the numerical columns.

##### Returns

The `tablesample` type containing the var (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to vDataframe using the `to_vdf` method.

##### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic.var()

5 #Output
                                variance
7 "age"                208.378019758472
  "body"               9326.92778502101
9 "survived"           0.231873084976754
  "pclass"             0.709782047186962
11 "parch"             0.754474138395633
  "fare"               2771.60900054498
13 "sibsp"             1.08392517492353

```

#### 8.2.4.90 version

```

1 vDataframe.version(self)

```

Returns the Vertica DB version and useful information on the vDataframe.

#### Example

```

1 titanic.version()

3 #Output

5 #
  # VERTICA-ML-PYTHON
7 #
  # Author: Badr Ouali, Datascientist at Vertica
9 #
  # You are currently using Vertica Analytic Database v9.2.1-0
11 #
  # You have a perfectly adapted version for using vDataframe and Vertica ML
13 #
  # For more information about the vDataframe you can use the help() method
15 (9, 2)

```

## 8.3 Virtual Column

### 8.3.1 attributes

When the vDataframe is created, it will creates as many vColumn as there are columns in the input relation. The vColumn has only 3 attributes.

- **parent**: the vColumn parent (must be a vDataframe).
- **alias**: the alias of the column.
- **transformations**: list of all the Virtual Column transformations.

### 8.3.2 methods

#### 8.3.2.1 abs

```
1 vColumn.abs(self)
```

Apply the abs function to the column elements.

#### Returns

The vColumn itself.

#### Example

```
1 from vertica_ml_python.vdataframe import vdf_from_relation
2 relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
3     x) UNION ALL (SELECT -9 AS x)) z"
4 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
5 vdf["x"]
6
7 #Output
8
9      x
10 0    5
11 1   -1
12 2    2
13 3   -9
14 Name: x, Number of rows: 4, dtype: int
15
16 vdf["x"].abs()
17
18 #Output
19
20      x
21 0    5
22 1    1
23 2    2
24 3    9
25 Name: x, Number of rows: 4, dtype: int
```

#### 8.3.2.2 add

```
vColumn.add(self, x: float)
```

Add a float to the column elements.

### Parameters

- **x:** *<float>*  
A float number.

### Returns

The vColumn itself.

### Example

```
1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
    x) UNION ALL (SELECT -9 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
  vdf["x"]
5
6 #Output
7      x
0      5
9     -1
10     2
11    -9
12 Name: x, Number of rows: 4, dtype: int
13
14 vdf["x"].add(x = 2)
15
16 #Output
17      x
18     7
19     1
20     4
21    -7
22 Name: x, Number of rows: 4, dtype: int
```

#### 8.3.2.3 add\_copy

```
vColumn.add_copy(self, name: str)
```

Add a column copy to the vDataFrame.

### Parameters

- **name:** <str>  
Copy name.

### Returns

The vColumn copy.

### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
    x) UNION ALL (SELECT -9 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5 #Output
      x
7 0    5
  1   -1
  2    2
  3   -9
11 Name: x, Number of rows: 4, dtype: int

13 vdf["x"].add_copy(name = "y")

15 #Output
      x      y
17 0    5      5
  1   -1     -1
  2    2      2
  3   -9     -9
21 Name: VDF, Number of rows: 4, Number of columns: 2

```

#### 8.3.2.4 add\_prefix

```

1 vColumn.add_prefix(self, prefix: str)

```

Add a prefix to each of the column element.

### Parameters

- **prefix:** <str>  
The prefix.

### Returns

The vColumn itself.



### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
      x) UNION ALL (SELECT -9 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
  vdf["x"]
5
#Output
7      x
0      5
9     -1
10     2
11    -9
Name: x, Number of rows: 4, dtype: int
13
vdf["x"].add_prefix(prefix = "elem_")
15
#Output
17      x
0    elem_5
19   elem_-1
20    elem_2
21   elem_-9
Name: x, Number of rows: 4, dtype: varchar(25)

```

#### 8.3.2.5 add\_suffix

```
vColumn.add_suffix(self, suffix: str)
```

Add a suffix to each of the column element.

#### Parameters

- **suffix:** <str>  
The suffix.

#### Returns

The vColumn itself.

### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
      x) UNION ALL (SELECT -9 AS x)) z"

```

```

3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
  vdf["x"]
5
  #Output
7      x
0      5
9     -1
10     2
11     -9
  Name: x, Number of rows: 4, dtype: int
13
  vdf["x"].add_suffix(prefix = "_end")
15
  #Output
17      x
0      5_end
19     -1_end
20     2_end
21     -9_end
  Name: x, Number of rows: 4, dtype: varchar(24)

```

### 8.3.2.6 aggregate / agg

```
vDataframe.aggregate(self, func: list)
```

Aggregate the columns using the input aggregations.

#### Parameters

- **func:** <list>  
List of the different aggregations.

#### Returns

The `tablesample` type containing the aggregations (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to `vDataframe` using the `to_vdf` method.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["age"].agg(["sum", "min"])
5
  #Output
6      "age"
7 sum    30062.0

```

min	0.33
-----	------

### 8.3.2.7 apply

```
vDataframe.apply(self, func: str, copy: bool = False, copy_name: str = "")
```

Apply the input function to the column.

#### Parameters

- **func:** <str>  
The function to apply. The function's variable must be written using flower brackets '{}' (Example: EXP({}))
- **copy:** <bool>, optional  
Create a copy of the column in the vDataframe and apply the function on it.
- **copy\_name:** <str>, optional  
Copy name.

#### Returns

The vColumn itself.

#### Example

```
1 from vertica_ml_python.vdataframe import vdf_from_relation
2 relation = "((SELECT 1 AS x, 4 AS y) UNION ALL (SELECT 2 AS x, 9 AS y)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

4
5 #Output
6      x      y
7 0     1     4
8 1     2     9
9 Name: VDF, Number of rows: 2, Number of columns: 2

10
11 vdf["x"].apply('EXP({})')

12
13 #Output
14      x      y
15 0 2.71828182845905     4
16 1 7.38905609893065     9
17 Name: VDF, Number of rows: 2, Number of columns: 2
```

### 8.3.2.8 astype

```
1 vColumn.astype(self, dtype: str)
```

Convert the column to a new data type.

#### Parameters

- **dtype:** <str>  
The new data type.

#### Returns

The vColumn itself.

#### Example

```
1 from vertica_ml_python.vdataframe import vdf_from_relation
2 relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
3 x) UNION ALL (SELECT -9 AS x)) z"
4 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
5 vdf["x"].dtype()
6
7 #Output
8 int
9
10 vdf["x"].astype(dtype = "varchar(3)").dtype()
11
12 #Output
13 varchar(3)
```

### 8.3.2.9 avg / mean

```
vColumn.avg(self)
```

Returns the column average.

#### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
3 titanic["age"].avg()
4
5 #Output
6 30.1524573721163
```

### 8.3.2.10 bar

```

vColumn.bar(
    self,
    method: str = "density",
    of: str = "",
    max_cardinality: int = 6,
    bins: int = 0,
    h: float = 0,
    color: str = '#214579')

```

Draw the column bar chart.

#### Parameters

- **method:** <str>, optional  
count | density | avg | min | max | sum  
count: count is used as aggregation  
density (default): density is used as aggregation  
avg | min | max | sum: these aggregations are used only if "of" is informed
- **of:** <str>, optional  
The column used to compute the aggregation. This variable is used only if "method" in {avg | min | max | sum}
- **max\_cardinality:** <int>, optional  
The maximum cardinality of the column. Under this number the column is automatically considered as categorical.
- **bins:** <int>, optional  
The number of bins of the histogram.
- **h:** <float>, optional  
The interval size of the column. It is used if the column is numerical. In the other case, if h is not informed. The best "h" will be computed automatically. If the column is a date, h represents the interval size in seconds.
- **color:** <str>, optional  
The histogram color.

#### Returns

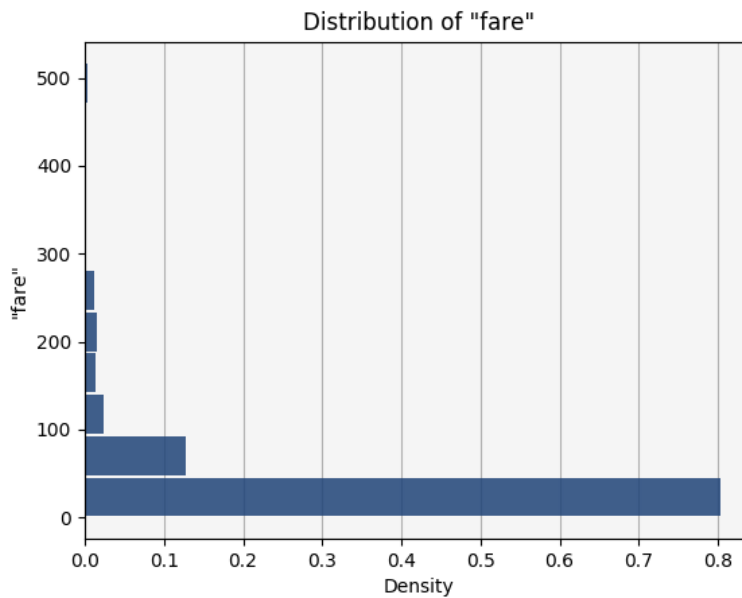
The vColumn itself.

#### Example

```

from vertica_ml_python.learn.datasets import load_titanic
titanic = load_titanic(cur)
titanic["fare"].bar()

```



### 8.3.2.11 boxplot

```

1 vColumn.boxplot (
2     self,
3     by: str = "",
4     h: float = 0,
5     max_cardinality: int = 8,
6     cat_priority: list = [])

```

Draw the column boxplot.

#### Parameters

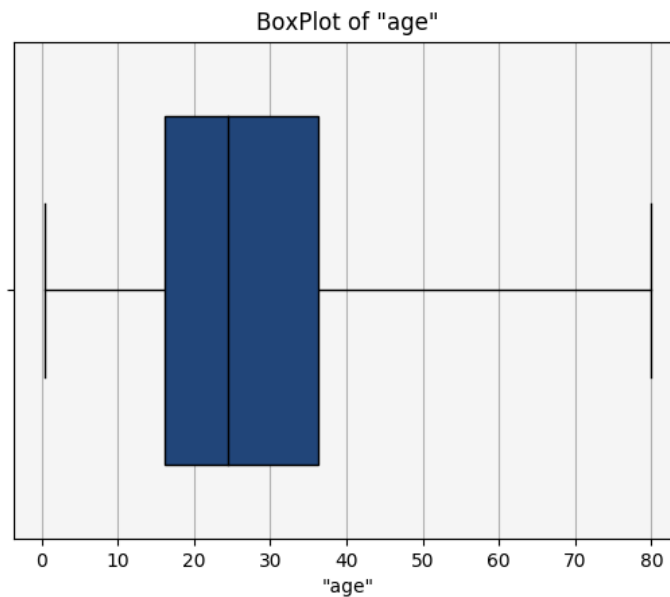
- **by:** <str>, optional  
The group by column. It is used to split the different categories to draw a multi boxplot.
- **max\_cardinality:** <int>, optional  
The maximum cardinality of the column. Under this number the column is automatically considered as categorical.
- **h:** <float>, optional  
The interval size of the column. It is used if the column is numerical. In the other case, if h is not informed. The best "h" will be computed automatically.
- **cat\_priority:** <list>, optional  
The principal categories to show.

#### Returns

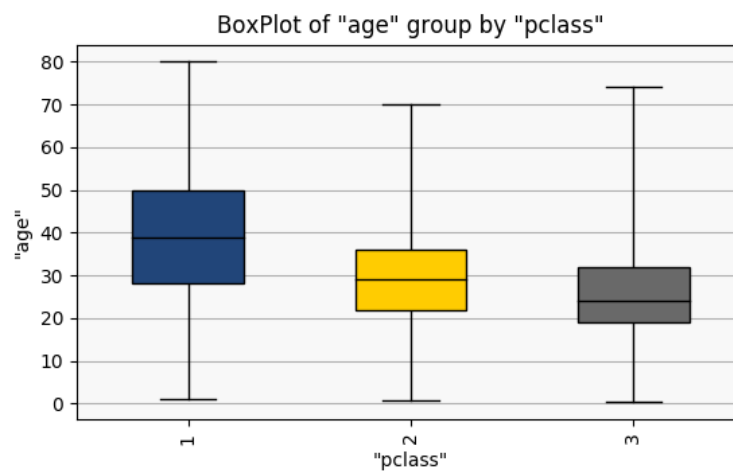
The vColumn itself.

## Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
3 titanic["age"].boxplot()
```



```
1 titanic["age"].boxplot(by = "pclass")
```



### 8.3.2.12 category

```
1 vColumn.category(self)
```

Returns the column category.

#### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["name"].category()

5 #Output
  text
```

### 8.3.2.13 clip

```
vColumn.clip(self, lower = None, upper = None)
```

Clip the data by transforming the values lesser than the lower bound to the lower bound itself and the values higher than the upper bound to the upper bound itself. The column will be transformed.

#### Parameters

- **lower:** <float>, optional  
Lower bound.
- **upper:** <float>, optional  
Upper bound.

#### Returns

The vColumn itself.

#### Example

```
1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "(SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
    x) UNION ALL (SELECT -9 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5 #Output
    x
7 0    5
  1   -1
9 2    2
```



```

3      -9
11 Name: x, Number of rows: 4, dtype: int

13 vdf["x"].clip(lower = -1, upper = 1)

15 #Output
      x
17 0    1
   1   -1
19 2    1
   3   -1
21 Name: x, Number of rows: 4, dtype: int

```

#### 8.3.2.14 count

```
1 vColumn.count(self)
```

Returns the column count (number of non-NULL elements).

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["age"].count()

5 #Output
  997

```

#### 8.3.2.15 date\_part

```
vColumn.date_part(self, field: str)
```

Extract a specific field from the column (only if the column is a timestamp). The column will be transformed.

#### Parameters

- **field:** <str>

The field to extract. It can be in {CENTURY | DAY | DECADE | DOQ | DOW | DOY | EPOCH | HOUR | ISODOW | ISOWEEK | ISOYEAR | MICROSECONDS | MILLENNIUM | MILLISECONDS | MINUTE | MONTH | QUARTER | SECOND | TIME\_ZONE | TIMEZONE\_HOUR | TIMEZONE\_MINUTE | WEEK | YEAR}

#### Returns

The vColumn itself.

## Example

```

1 from vertica_ml_python.learn.datasets import load_smart_meters
  sm = load_smart_meters(cur)
3
4 #Output
5           time           val      id
6 0  2014-01-01 01:15:00   0.0370000    2
7 1  2014-01-01 02:30:00   0.0800000    5
8 2  2014-01-01 03:00:00   0.0810000    1
9 3  2014-01-01 05:00:00   1.4890000    3
10 4  2014-01-01 06:00:00   0.0720000    5
11 ...      ...      ...      ...
12 Name: smart_meters, Number of rows: 11844, Number of columns: 3
13
14 sm["time"].date_part("month")
15
16 #Output
17      time      val      id
18 0      1      0.0370000    2
19 1      1      0.0800000    5
20 2      1      0.0810000    1
21 3      1      1.4890000    3
22 4      1      0.0720000    5
23 ...      ...      ...      ...
24 Name: smart_meters, Number of rows: 11844, Number of columns: 3

```

### 8.3.2.16 decode

```
vColumn.decode(self, values: dict, others = None)
```

Encode the data using the input bijection.

#### Parameters

- **values:** <dict>  
Dictionary of values representing the bijection used to encode the data.
- **others:** <float>, optional  
How to encode the values which are not in the dictionary of values.

#### Returns

The vColumn itself.

## Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["sex"]

5 #Output
      sex
7 0    female
  1     male
9 2    female
  3     male
11 4     male
   ...    ...
13 Name: sex, Number of rows: 1234, dtype: varchar(20)

15 titanic["sex"].decode(values = {"male": 1, "female": 0})

17 #Output
      sex
19 0      0
  1      1
21 2      0
  3      1
23 4      1
   ...    ...
25 Name: sex, Number of rows: 1234, dtype: int

```

### 8.3.2.17 density

```

1 vColumn.density(
      self,
3      a = None,
      kernel: str = "gaussian",
5      smooth: int = 200,
      color: str = '#214579')

```

Draw the column density plot.

#### Parameters

- **a:** <float>, optional  
The kernel window. If it is not informed, an optimal one is computed.
- **kernel:** <str>, optional  
gaussian (default) | logistic | sigmoid | silverman  
The Kernel used for the plot.

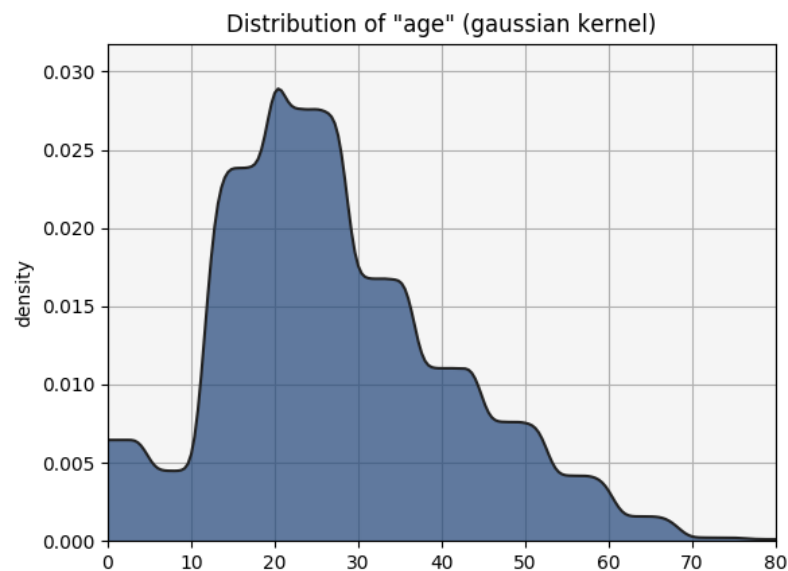
- **smooth:** *<positive int>*, optional  
The number of points used for the smoothing.
- **color:** *<str>*, optional  
The density plot color.

### Returns

The vColumn itself.

### Example

```
from vertica_ml_python.learn.datasets import load_titanic
titanic = load_titanic(cur)
titanic["age"].density()
```



#### 8.3.2.18 describe

```
vColumn.describe(method: str = "auto", max_cardinality: int = 6)
```

Summarise the column with mathematical information.

### Parameters

- **method:** *<str>*, optional  
auto | categorical | numerical | cat\_stats  
auto (default): This mode is used to detect the correct category.  
numerical: This mode is used to print numerical information if it is possible.  
categorical: This mode is used to only print the categorical variables information (text or *cardinality*  $\leq$  *max\_cardinality*).  
cat\_stats: This mode is used to compute descriptive statistics

- **max\_cardinality:** *<bool>*, optional

The maximum cardinality of the column. Under this number the column is automatically considered as categorical.

## Returns

The `tablesample` type containing the mathematical information (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to `vDataFrame` using the `to_vdf` method.

## Note

The mathematical information are different depending on the data type and if they are categorical.

## Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["age"].describe()

5 #Output
                                value
7 name                          "age"
  dtype          numeric(6,3)
9 unique                      96
  count              997.0
11 mean          30.1524573721163
  std           14.4353046299159
13 min              0.33
  25%              21.0
15 50%              28.0
  75%              39.0
17 max              80.0

19 titanic["pclass"].describe()

21 #Output
                                value
23 name                          "pclass"
  dtype              int
25 unique                      3
  3              663
27 1              312
  2              259

```

### 8.3.2.19 distinct

```
vColumn.distinct(self)
```

Returns all the columns distinct elements.

### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["pclass"].distinct()

5 #Output
  [1, 2, 3]
```

#### 8.3.2.20 divide / div

```
vColumn.divide(self, x: float)
```

Div the column by a float.

### Parameters

- **x:** *<float>*  
A float number ( $\neq 0$ ).

### Returns

The vColumn itself.

### Example

```
1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
    x) UNION ALL (SELECT -9 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
  vdf["x"]

5 #Output
7      x
0      5
9     -1
2      2
11     -9
  Name: x, Number of rows: 4, dtype: int

13 vdf["x"].div(x = 5)

15 #Output
17      x
```

```

0      1.00000000000000000000
19 1      -0.20000000000000000000
2      0.40000000000000000000
21 3      -1.80000000000000000000
Name: x, Number of rows: 4, dtype: numeric(36,18)

```

### 8.3.2.21 donut

```

vColumn.donut(
2     self,
     method: str = "density",
4     of: str = "",
     max_cardinality: int = 6,
6     h: float = 0)

```

Draw the column donut chart.

#### Parameters

- **method:** <str>, optional  
count | density | avg | min | max | sum  
count: count is used as aggregation  
density (default): density is used as aggregation  
avg | min | max | sum: these aggregations are used only if "of" is informed
- **of:** <str>, optional  
The column used to compute the aggregation. This variable is used only if "method" in {avg | min | max | sum}
- **max\_cardinality:** <positive int>, optional  
The maximum cardinality of the column. Under this number the column is automatically considered as categorical.
- **h:** <float>, optional  
The interval size of the column. It is used if the column is numerical. In the other case, if h is not informed. The best "h" will be computed automatically. If the column is a date, h represents the interval size in seconds.

#### Returns

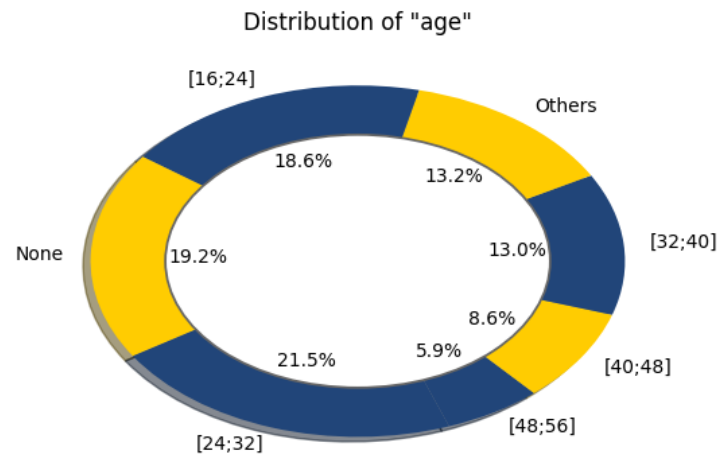
The vColumn itself.

#### Example

```

from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
titanic["age"].donut()

```



### 8.3.2.22 drop

```
1 vColumn.drop(self)
```

Drop the column from the vDataFrame.

#### Returns

The parent vDataFrame.

#### Example

```
1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT 5 AS x, -1 AS y) UNION ALL (SELECT -1 AS x, 10 AS y)
           UNION ALL (SELECT 2 AS x, 3 AS y)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5 #Output
      x      y
7 0    5     -1
  1   -1    10
  2    2      3
9 Name: VDF, Number of rows: 3, Number of columns: 2

11 vdf["x"].drop()

13 #Output
15      y
```



```

0      -1
1      10
2       3
19 Name: y, Number of rows: 3, dtype: int

```

### 8.3.2.23 dropna

```
1 vColumn.dropna(self)
```

Drop the elements having missing values.

#### Returns

The vColumn itself.

#### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT 5 AS x, -1 AS y) UNION ALL (SELECT NULL AS x, 10 AS y)
           UNION ALL (SELECT 2 AS x, 3 AS y)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5 #Output
      x      y
7 0      5     -1
1 1   None    10
9 2      2      3
Name: VDF, Number of rows: 3, Number of columns: 2

11 vdf["x"].dropna()

13 #Output
      x      y
15 0      5     -1
17 1      2      3
Name: VDF, Number of rows: 2, Number of columns: 2

```

### 8.3.2.24 drop\_outliers

```
vColumn.drop_outliers(self, alpha: float = 0.05)
```

Drop the columns outliers.

#### Parameters

- **alpha:** <float>

Number representing the outliers threshold. Values lesser than quantile(alpha) or greater than quantile(1-alpha) will be dropped.

## Returns

The vColumn itself.

## Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
      x) UNION ALL (SELECT -9 AS x) UNION ALL (SELECT -600 AS x) UNION ALL (
      SELECT 100000 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
vdf["x"]
5
#Output
7      x
0      5
9     -1
10     2
11    -9
12   -600
13 100000
Name: x, Number of rows: 6, dtype: int
15
vdf["x"].div(x = 5)
17
#Output
19      x
20     5
21    -1
22     2
23    -9
Name: x, Number of rows: 4, dtype: int

```

### 8.3.2.25 dtype

```
vColumn.dtype(self)
```

Returns the column data type.

## Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["name"].dtype()

5 #Output
  varchar(164)
```

#### 8.3.2.26 ema

```
ema(self, ts: str, by: list = [], alpha: float = 0.5)
```

Compute the exponential moving average of the column using an input time series.

##### Parameters

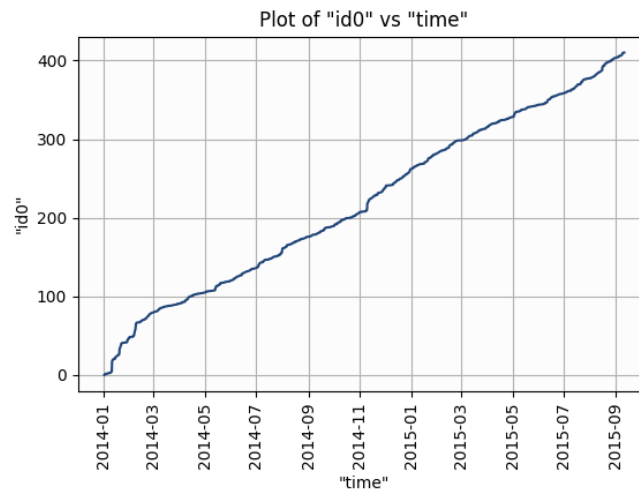
- **ts:** <str>  
The vDataframe time series.
- **by:** <list>, optional  
How to group the data.
- **alpha:** <float>, optional  
the EMA smoothing factor.

##### Returns

The vColumn itself.

##### Example

```
1 from vertica_ml_python.learn.datasets import load_smart_meters
  sm = load_smart_meters(cur)
3 # Computing the cum sum of each home
  sm.cumsum(name = "val_cumsum", column = "val", by = ["id"], order_by = ["time"
    ])
5 # Building the features corresponding to the cum consumption of the home id 0
  sm.eval("id0", "DECODE(id, 0, val_cumsum, NULL)")
7 # Applying the EMA
  sm["id0"].ema(ts = "time", by = ["id"])
9 # Drawing the time series
  sm["id0"].plot(ts = "time")
```



### 8.3.2.27 equals / eq

```
vColumn.equals(self, x)
```

Verify if each element of the column is equal to the input element.

#### Parameters

- **x:** *<anytype>*  
Float, int or varchar.

#### Returns

The vColumn itself.

#### Example

```
1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
      x) UNION ALL (SELECT -9 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
vdf["x"]
5
#Output
7      x
0      5
9     -1
2      2
11     -9
Name: x, Number of rows: 4, dtype: int
13
```

```

vdf["x"].eq(x = -1)
#Output
      x
0   False
1    True
2   False
3   False
Name: x, Number of rows: 4, dtype: boolean

```

### 8.3.2.28 fillna

```

vDataframe.fillna(
    self,
    val = None,
    method: str = "auto",
    by: list = [],
    order_by: list = [])

```

Fill the missing values using the input method. If the parameters `val` and `method` are empty, all the missing values will be filled automatically (using the average of the column for the numerical columns and the mode for the categorical ones)

#### Parameters

- **val:** *<anytype>*, optional  
Constant value used to impute the column.
- **method:** *<dict>*, optional  
Method used to impute the column.  
auto | avg | median | mode | ffill | backfill  
auto (default): average for numerical and mode for categorical.  
avg: Imputation using the column average.  
median: Imputation using the column median.  
mode: Imputation using the column mode (most occurrent element).  
ffill: Propagation of the first non-NULL element = constant interpolation (only for time series, `order_by` parameter must be defined).  
bfill: Back Propagation of the next non-NULL element = constant interpolation (only for time series, `order_by` parameter must be defined).
- **by:** *<list>*, optional  
The columns used to group the main one.
- **order\_by:** *<list>*, optional  
The columns used to order the data (used only when method is `bfill` or `ffill`)

#### Returns

The `vColumn` itself.

## Example

```

from vertica_ml_python.vdataframe import vdf_from_relation
2 relation = "((SELECT 5 AS x) UNION ALL (SELECT NULL AS x) UNION ALL (SELECT 2
    AS x) UNION ALL (SELECT NULL AS x) UNION ALL (SELECT -2 AS x) UNION ALL (
    SELECT 12 AS x)) z"
vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
4
#Output
6      x
0      5
8  1  None
2      2
10 3  None
4     -2
12 5     12
Name: x, Number of rows: 6, dtype: int
14
vdf["x"].fillna()
16
#Output
18      x
0     5.00
20 1     4.25
2     2.00
22 3     4.25
4    -2.00
24 5    12.00
Name: x, Number of rows: 6, dtype: float

```

### 8.3.2.29 fill\_outliers

```

1 vDataframe.fill_outliers(self, method: str = "winsorize", alpha = 0.05)

```

Fill the outliers using the input method.

#### Parameters

- **method:** <dict>, optional  
Method used to fill the column outliers.  
winsorize | null | mean  
winsorize (default): clip the data using as lower bound quantile(alpha) and as upper bound quantile(1-alpha).  
null: Replace the outliers by the NULL value.  
mean: Replace the upper and lower outliers by their respective average.
- **alpha:** <float>  
Number representing the outliers threshold. Values lesser than quantile(alpha) or greater than quantile(1-alpha) will be filled.

## Returns

The vColumn itself.

## Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT 5 AS x) UNION ALL (SELECT 600 AS x) UNION ALL (SELECT 2
      AS x) UNION ALL (SELECT -100 AS x) UNION ALL (SELECT -2 AS x) UNION ALL (
      SELECT 12 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5 #Output
      x
7 0      5
1 1     600
9 2      2
3 3    -100
11 4     -2
5 5     12
13 Name: x, Number of rows: 6, dtype: int

15 vdf["x"].fill_outliers(method = "null")

17 #Output
      x
19 0      5
1 1    None
21 2      2
3 3    None
23 4     -2
5 5     12
25 Name: x, Number of rows: 6, dtype: int

```

### 8.3.2.30 ge

```

1 vColumn.ge(self, x: float)

```

Verify if each element of the column is greater or equal to the input element.

## Parameters

- **x:** <float>  
A numerical element.

## Returns

The vColumn itself.

### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
      x) UNION ALL (SELECT -9 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
vdf["x"]
5
#Output
7      x
0      5
9     -1
10     2
11    -9
Name: x, Number of rows: 4, dtype: int
13
vdf["x"].ge(x = 2)
15
#Output
17      x
0     True
19    False
20     True
21    False
Name: x, Number of rows: 4, dtype: boolean

```

#### 8.3.2.31 get\_dummies

```

vColumn.get_dummies(
2     self,
      prefix: str = "",
4     prefix_sep: str = "_",
      drop_first: bool = False,
6     use_numbers_as_suffix: bool = False)

```

Compute the different columns dummies and add them to the vDataFrame.

#### Parameters

- **prefix:** <str>, optional  
Prefix of the dummies.
- **prefix\_sep:** <str>, optional  
Prefix delimiter of the dummies.



- **drop\_first:** *<bool>*, optional  
Drop the first dummy to avoid the creation of correlated features.
- **use\_numbers\_as\_suffix:** *<bool>*, optional  
Use numbers as suffix instead of the different categories.

### Returns

The vColumn itself.

### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
3 titanic = titanic.select(["embarked"])
4
5 #Output
6      embarked
7 0           S
8 1           S
9 2           S
10 3           S
11 4           C
12 ...      ...
13 Name: embarked, Number of rows: 1234, dtype: varchar(20)
14
15 titanic["embarked"].get_dummies()
16
17 #Output
18      embarked      embarked_C      embarked_Q      embarked_S
19 0           S              0              0              1
20 1           S              0              0              1
21 2           S              0              0              1
22 3           S              0              0              1
23 4           C              1              0              0
24 ...      ...              ...              ...              ...
25 Name: titanic, Number of rows: 1234, Number of columns: 4

```

#### 8.3.2.32 gt

```

1 vColumn.gt(self, x: float)

```

Verify if each element of the column is greater to the input element.

### Parameters

- **x:** *<float>*  
A numerical element.

### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
    x) UNION ALL (SELECT -9 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
  vdf["x"]
5
#Output
7      x
0      5
9     -1
10     2
11    -9
  Name: x, Number of rows: 4, dtype: int
13
  vdf["x"].gt(x = 2)
15
#Output
17      x
0     True
19    False
20    False
21    False
  Name: x, Number of rows: 4, dtype: boolean

```

#### 8.3.2.33 head

```
vColumn.head(self, limit: int = 5)
```

Returns the column head.

#### Parameters

- **limit:** <int>, optional  
The number of elements to return.

#### Returns

The `tablesample` type containing the column head (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to `vDataFrame` using the `to_vdf` method.

### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)

```

```

3 titanic["fare"].head(limit = 5)

5 #Output
      fare
7 0    151.55000
  1    151.55000
9 2    151.55000
  3     0.00000
11 4    49.50420
   ...
13 Name: fare, Number of rows: 1234, dtype: numeric(10,5)

```

### 8.3.2.34 hist

```

1 vColumn.hist(
      self,
3      method: str = "density",
      of: str = "",
5      max_cardinality: int = 6,
      bins: int = 0,
7      h: float = 0,
      color: str = '#214579')

```

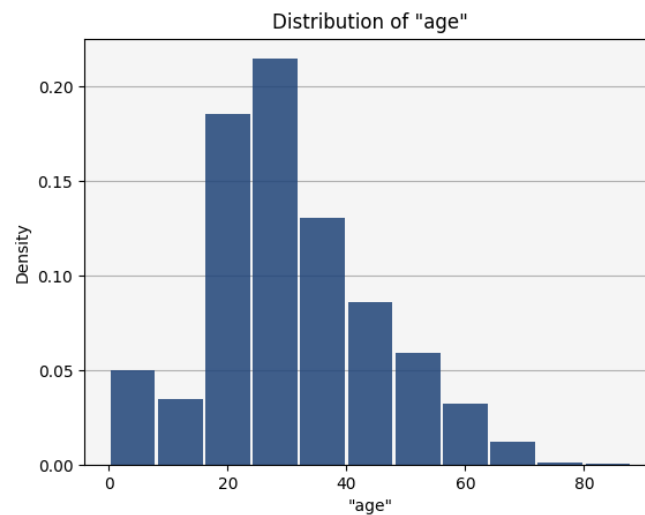
Draw the column histogram.

#### Parameters

- **method:** <str>, optional  
count | density | avg | min | max | sum  
count: count is used as aggregation  
density (default): density is used as aggregation  
avg | min | max | sum: these aggregations are used only if "of" is informed
- **of:** <str>, optional  
The column used to compute the aggregation. This variable is used only if "method" in {avg | min | max | sum}
- **max\_cardinality:** <int>, optional  
The maximum cardinality of the column. Under this number the column is automatically considered as categorical.
- **bins:** <int>, optional  
The number of bins of the histogram.
- **h:** <float>, optional  
The interval size of the column. It is used if the column is numerical. In the other case, if h is not informed. The best "h" will be computed automatically. If the column is a date, h represents the interval size in seconds.
- **color:** <str>, optional  
The histogram color.

### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
3 titanic["age"].hist()
```



#### 8.3.2.35 isdate

```
1 vColumn.isdate(self)
```

Returns True if the column is a date.

### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
3 titanic["age"].isdate()
4
5 #Output
6 False
```

#### 8.3.2.36 isin

```
vDataframe.isin(self, val: list)
```

Verify if the different elements are in the column.

### Parameters

- **val:** *<list>*  
List of values to check.

### Returns

The list containing the booleans

### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 # We verify if there was someone having 18 years old and someone having 52
  years old
  titanic["age"].isin(val = ["18", "52"])
5
  #Output
7 [True, True]
```

#### 8.3.2.37 isnum

```
1 vColumn.isnum(self)
```

Returns True if the column is numerical.

### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["age"].isnum()
5
  #Output
  True
```

#### 8.3.2.38 kurtosis / kurt

```
vColumn.kurtosis(self)
```

Returns the column unbiased kurtosis using Fisher's definition.

### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["age"].kurt()

5 #Output
  0.15689691331997

```

### 8.3.2.39 label\_encode

```
vColumn.label_encode(self)
```

Encode the column using a bijection from the different categories to  $[0, n - 1]$  ( $n$  being the number of elements).

#### Returns

The vColumn itself.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic = titanic.select(["embarked"])

5 #Output
   embarked
7 0         S
  1         S
9 2         S
  3         S
11 4         C
   ...     ...
13 Name: embarked, Number of rows: 1234, dtype: varchar(20)

15 titanic["embarked"].label_encode()

17 #Output
   embarked
19 0         2
  1         2
21 2         2
  3         2
23 4         0
   ...     ...
25 Name: embarked, Number of rows: 1234, dtype: int

```

### 8.3.2.40 le

```
vColumn.le(self, x: float)
```

Verify if each element of the column is lesser or equal to the input element.

#### Parameters

- **x:** *<float>*  
A numerical element.

#### Returns

The vColumn itself.

#### Example

```
1 from vertica_ml_python.vdataframe import vdf_from_relation
2 relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
   x) UNION ALL (SELECT -9 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
4 vdf["x"]
5
6 #Output
7      x
8 0      5
9 1     -1
10 2      2
11 3     -9
12 Name: x, Number of rows: 4, dtype: int
13
14 vdf["x"].le(x = 2)
15
16 #Output
17      x
18 0  False
19 1   True
20 2   True
21 3   True
22 Name: x, Number of rows: 4, dtype: boolean
```

### 8.3.2.41 lt

```
vColumn.lt(self, x: float)
```

Verify if each element of the column is lesser to the input element.

### Parameters

- **x:** *<float>*  
A numerical element.

### Returns

The vColumn itself.

### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
      x) UNION ALL (SELECT -9 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
vdf["x"]
5
#Output
7      x
0      5
9     -1
10     2
11    -9
Name: x, Number of rows: 4, dtype: int
13
vdf["x"].lt(x = 2)
15
#Output
17      x
0    False
19     True
20    False
21     True
Name: x, Number of rows: 4, dtype: boolean

```

#### 8.3.2.42 mad

```
vColumn.mad(self)
```

Returns the mean absolute deviation of the column.

### Example



```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["age"].mad()

5 #Output
  11.254785419447906
```

#### 8.3.2.43 max

```
vColumn.max(self)
```

Returns the column max.

##### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["age"].max()

5 #Output
  80.0
```

#### 8.3.2.44 mean\_encode

```
vColumn.mean_encode(self, response_column: str)
```

Encode the column using the average of the response column for the different categories.

##### Parameters

- **response\_column:** <str>  
The response column.

##### Returns

The vColumn itself.

##### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic = titanic.select(["embarked", "survived"])
```

```

5 #Output
      survived      embarked
7 0          0          S
  1          0          S
9 2          0          S
  3          0          S
11 4          0          C
   ...      ...      ...
13 Name: titanic, Number of rows: 1234, Number of columns: 2

15 titanic["embarked"].mean_encode(response_column = "survived")

17 #Output
      survived      embarked
19 0          1  0.537549407114625
  1          1  0.537549407114625
21 2          1  0.537549407114625
  3          1  0.537549407114625
23 4          1  0.537549407114625
   ...      ...      ...
25 Name: titanic, Number of rows: 1234, Number of columns: 2

```

#### 8.3.2.45 median

```
1 vColumn.median(self)
```

Returns the column median.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["age"].median()

5 #Output
  28.0

```

#### 8.3.2.46 min

```
vColumn.min(self)
```

Returns the column min.

### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["age"].min()

5 #Output
  0.33

```

#### 8.3.2.47 mod

```
vColumn.mod(self, n: int)
```

Apply the mod(n) function to the column elements.

#### Parameters

- **n:** *<int>*  
An integer.

#### Returns

The vColumn itself.

### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
    x) UNION ALL (SELECT -9 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
  vdf["x"]

5 #Output
7      x
0      5
9     -1
2      2
11     -9
  Name: x, Number of rows: 4, dtype: int

13 vdf["x"].mod(n = 2)

15 #Output
17      x
0      1
19     -1

```

```
2      0
21 3     -1
Name: x, Number of rows: 4, dtype: int
```

#### 8.3.2.48 mode

```
vColumn.mode(self, dropna: bool = True)
```

Returns the column mode (most occurrent element).

##### Parameters

- **dropna:** *<bool>*, optional  
Do not consider null values as a category.

##### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["pclass"].mode()

5 #Output
  3
```

#### 8.3.2.49 mul

```
vColumn.mul(self, x: float)
```

Multiply all the column elements by a float.

##### Parameters

- **x:** *<float>*  
A number.

##### Returns

The vColumn itself.

##### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
      x) UNION ALL (SELECT -9 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
vdf["x"]
5
#Output
7      x
0      5
9     -1
10     2
11    -9
Name: x, Number of rows: 4, dtype: int
13
vdf["x"].mul(x = 3)
15
#Output
17      x
0     15
19     -3
20     6
21    -27
Name: x, Number of rows: 4, dtype: int

```

### 8.3.2.50 neq

```
vColumn.neq(self, x)
```

Verify if each element of the column is not equal to the input element.

#### Parameters

- **x:** <anytype>  
Float, int or varchar.

#### Returns

The vColumn itself.

#### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
      x) UNION ALL (SELECT -9 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

```

```

vdf["x"]
5
#Output
7      x
0      5
9     -1
10     2
11    -9
Name: x, Number of rows: 4, dtype: int
13
vdf["x"].neq(x = -1)
15
#Output
17      x
0     True
19    False
20     True
21     True
Name: x, Number of rows: 4, dtype: boolean

```

#### 8.3.2.51 next

```
vColumn.next(self, order_by: list, by: list = [])
```

Replace the element of the column by the next one.

#### Parameters

- **order\_by:** <list>  
How to order the data.
- **by:** <list>, optional  
How to group the data.

#### Returns

The vColumn itself.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_smart_meters
sm = load_smart_meters(cur)
3 sm["val"].add_copy("next")
sm["next"].next(order_by = ["time"], by = ["id"])
5
#Output
7      time      val      id      next

```

```

0      2014-01-01 11:00:00      0.0290000      0      0.2770000
9 1      2014-01-01 13:45:00      0.2770000      0      0.3210000
2      2014-01-02 10:45:00      0.3210000      0      0.3050000
11 3      2014-01-02 11:15:00      0.3050000      0      0.3580000
4      2014-01-02 13:45:00      0.3580000      0      0.1150000
13 ...      ...      ...      ...      ...
Name: smart_meters, Number of rows: 11844, Number of columns: 4

```

### 8.3.2.52 normalize

```
vColumn.normalize(self, method: str = "zscore")
```

normalize the column with a specific method.

#### Parameters

- **method:** <str>, optional  
zscore (default) | robust\_zscore | minmax  
The method used for the normalization.

#### Returns

The vColumn itself.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
titanic = load_titanic(cur)
3 titanic["fare"].normalize()

5 #Output
                                     fare
7 0      2.2335228377568673306163744003
1 1      2.2335228377568673306163744003
9 2      2.2335228377568673306163744003
3 3      -0.6451344183800711827483251581
11 4      0.2951864297839290254556257484
...      ...
13 Name: fare, Number of rows: 1234, dtype: float

```

### 8.3.2.53 numh

```
1 vColumn.numh(self, method: str = "auto")
```

Returns the interval size to convert the column to categorical using a specific method.

### Parameters

- **method:** <str>, optional  
 auto | sturges | freedman\_diaconis  
 auto (default): max of the interval computed by the two available method.  
 sturges: Use Sturges definition of the best h.  
 freedman\_diaconis: Use Freedman Diaconis definition of the best h.

### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["fare"].numh()

5 #Output
  47
```

#### 8.3.2.54 nunique

```
vColumn.nunique(self)
```

Returns the column cardinality.

### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["pclass"].nunique()

5 #Output
  3
```

#### 8.3.2.55 pct\_change

```
vColumn.pct_change(self, order_by: list, by: list = [])
```

Compute the ratio between the current value and the previous one. The column will be transformed.

### Parameters

- **order\_by:** <list>  
 The list of elements to order the vDataframe during the process.



- **by:** <list>, optional  
The columns used to group the main column.

### Example

```

1 from vertica_ml_python.learn.datasets import load_smart_meters
  sm = load_smart_meters(cur)
3
4 #Output
5
6      time      val      id
7 0  2014-01-01 01:15:00  0.0370000  2
8 1  2014-01-01 02:30:00  0.0800000  5
9 2  2014-01-01 03:00:00  0.0810000  1
10 3  2014-01-01 05:00:00  1.4890000  3
11 4  2014-01-01 06:00:00  0.0720000  5
12 ...
13 Name: smart_meters, Number of rows: 11844, Number of columns: 3
14
15 sm["val"].pct_change(order_by = ["time"], by = ["id"])
16
17 #Output
18
19      time      val      id
20 0  2014-01-01 11:00:00  9.551724137931034483  0
21 1  2014-01-01 13:45:00  1.158844765342960289  0
22 2  2014-01-02 10:45:00  0.950155763239875389  0
23 3  2014-01-02 11:15:00  1.173770491803278689  0
24 4  2014-01-02 13:45:00  0.321229050279329609  0
25 ...
26 Name: smart_meters, Number of rows: 11844, Number of columns: 3

```

### 8.3.2.56 pie

```

1 vColumn.pie(
2     self,
3     method: str = "density",
4     of: str = "",
5     max_cardinality: int = 6,
6     h: float = 0)

```

Draw the column pie chart.

### Parameters

- **method:** <str>, optional  
count | density | avg | min | max | sum  
count: count is used as aggregation

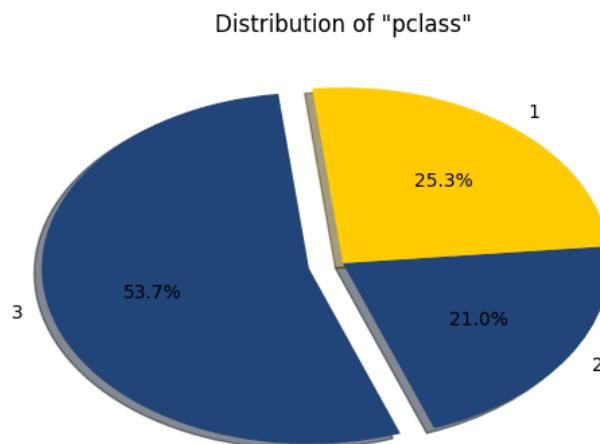
density (default): density is used as aggregation

avg | min | max | sum: these aggregations are used only if "of" is informed

- **of:** *<str>*, optional  
The column used to compute the aggregation. This variable is used only if "method" in {avg | min | max | sum}
- **max\_cardinality:** *<positive int>*, optional  
The maximum cardinality of the column. Under this number the column is automatically considered as categorical.
- **h:** *<float>*, optional  
The interval size of the column. It is used if the column is numerical. In the other case, if h is not informed. The best "h" will be computed automatically. If the column is a date, h represents the interval size in seconds.

### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
3 titanic["pclass"].pie()
```



#### 8.3.2.57 plot

```
1 vDataframe.plot(
2     self,
3     ts: str,
4     by: str,
5     start_date: str = "",
6     end_date: str = ""
7     color: str = '#214579',
```

```
area: bool = False )
```

Plot the time series of the column.

### Parameters

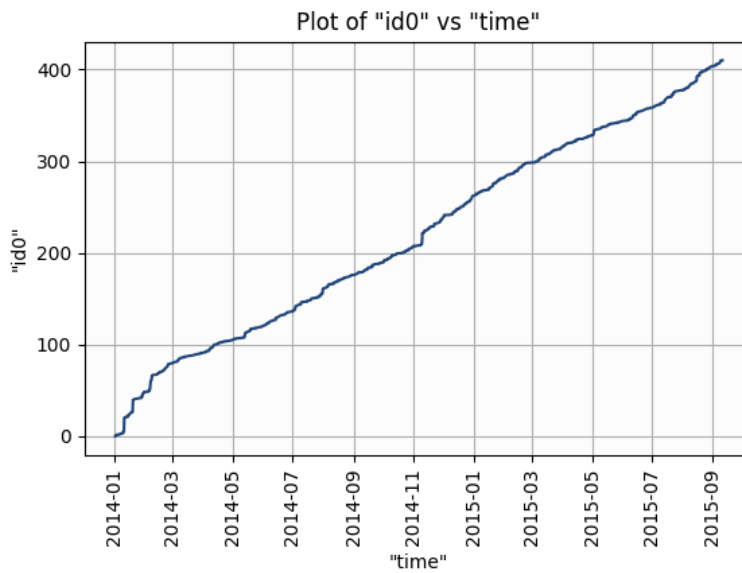
- **ts:** *<str>*  
The time series used to plot the different elements.
- **by:** *<str>*, optional  
The column to group with.
- **start\_date:** *<str>*, optional  
Start Date.
- **end\_date:** *<str>*, optional  
End Date.
- **color:** *<str>*, optional  
Plot color.
- **area:** *<bool>*, optional  
To plot an area plot.

### Returns

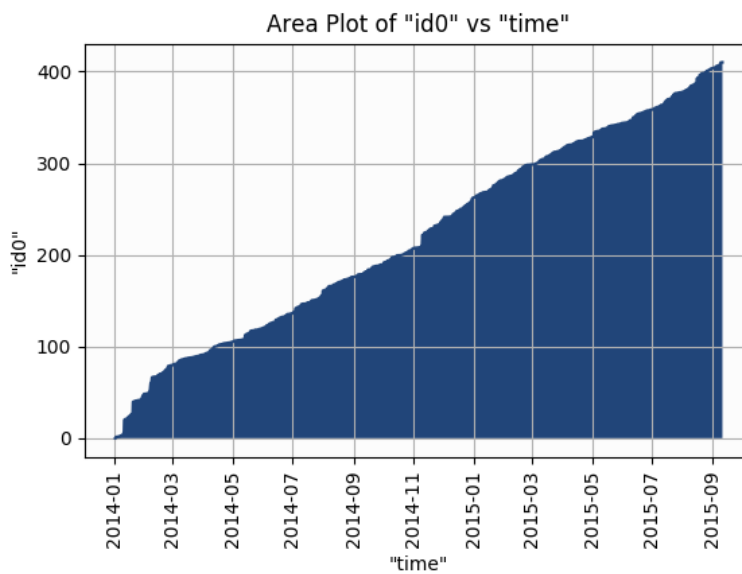
The vColumn itself.

### Example

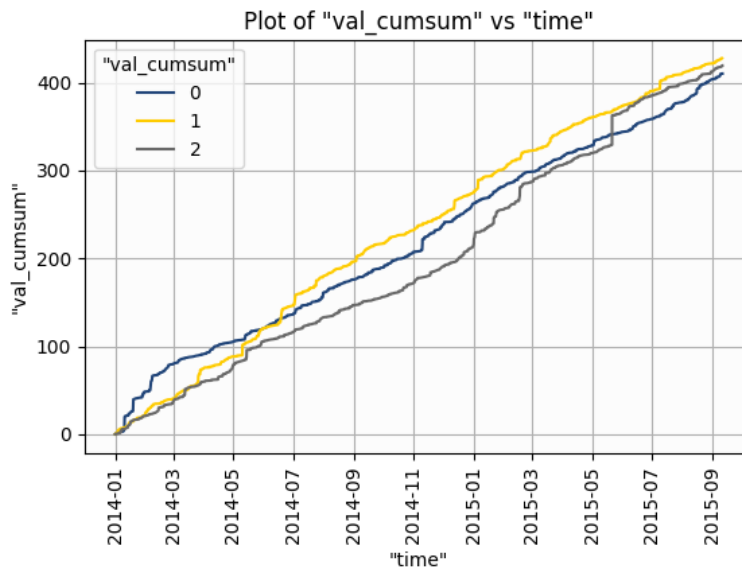
```
from vertica_ml_python.learn.datasets import load_smart_meters
2 sm = load_smart_meters(cur)
  # Computing the cum sum of each home
4 sm.cumsum(name = "val_cumsum", column = "val", by = ["id"], order_by = ["time"
  ])
  # Building the features corresponding to the cum consumption of the home id 0
6 sm.eval("id0", "DECODE(id, 0, val_cumsum, NULL)")
  # Drawing the time series
8 sm["id0"].plot(ts = "time")
```



```
sm["id0"].plot(ts = "time", area = True)
```



```
1 # Plot by grouping by id
sm.cumsum(name = "val_cumsum", column = "val", by = ["id"], order_by = ["time"]
2         ).filter("id <= 2")
3 sm["val_cumsum"].plot(ts = "time", by = "id")
```



### 8.3.2.58 pow

```
1 vColumn.pow(self, x: float)
```

Apply the pow(x) function to the column elements.

#### Parameters

- **x:** <float>  
A float representing the power exponent.

#### Returns

The vColumn itself.

#### Example

```
1 from vertica_ml_python.vdataframe import vdf_from_relation
2 relation = "( (SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
3 x) UNION ALL (SELECT -9 AS x)) z"
4 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
5 vdf["x"]
6
7 #Output
8
9 x
10 0      5
11 1     -1
12 2      2
```

```

11 3      -9
    Name: x, Number of rows: 4, dtype: int
13
15 vdf["x"].pow(x = 2)
17
19 #Output
    x
0    25.0
1     1.0
2     4.0
21 3    81.0
    Name: x, Number of rows: 4, dtype: float

```

### 8.3.2.59 prev

```
vColumn.prev(self, order_by: list, by: list = [])
```

Replace the element of the column by the previous one.

#### Parameters

- **order\_by:** <list>  
How to order the data.
- **by:** <list>, optional  
How to group the data.

#### Returns

The vColumn itself.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_smart_meters
  sm = load_smart_meters(cur)
3 sm["val"].add_copy("prev")
  sm["next"].prev(order_by = ["time"], by = ["id"])
5
  #Output
7
   time          val    id    prev
0  2014-01-01 11:00:00  0.0290000  0    None
9  2014-01-01 13:45:00  0.2770000  0    0.0290000
2  2014-01-02 10:45:00  0.3210000  0    0.2770000
11 2014-01-02 11:15:00  0.3050000  0    0.3210000
4  2014-01-02 13:45:00  0.3580000  0    0.3050000
13 ...          ...          ...    ...
    Name: smart_meters, Number of rows: 11844, Number of columns: 4

```

### 8.3.2.60 product / prod

```
vColumn.prod(self)
```

Returns the column product.

#### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["survived"].prod()

5 #Output
  0.0
```

### 8.3.2.61 quantile

```
vColumn.quantile(self, x: float)
```

Returns the column selected quantile.

#### Parameters

- **x:** <float>  
A float living in [0,1] representing the quantile.

#### Example

```
1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
    x) UNION ALL (SELECT -9 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
  vdf["x"]

5 #Output
7      x
0      5
9     -1
2      2
11     -9
  Name: x, Number of rows: 4, dtype: int

13 vdf["x"].quantile(x = 0.1)

15 #Output
```

```
17 -6.6
```

### 8.3.2.62 rename

```
1 vColumn.rename(self, new_name: str)
```

Change the column alias.

#### Parameters

- **new\_name:** *<str>*  
New alias.

#### Returns

The vColumn itself.

#### Example

```
1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
           x) UNION ALL (SELECT -9 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5 #Output
      x
7 0    5
  1   -1
9 2    2
  3   -9
11 Name: x, Number of rows: 4, dtype: int

13 vdf["x"].rename(new_name = "y")

15 #Output
      y
17 0    5
  1   -1
19 2    2
  3   -9
21 Name: y, Number of rows: 4, dtype: int
```

### 8.3.2.63 round



```
1 vColumn.round(self, n: int)
```

Round the column elements with the input integer.

### Parameters

- **n:** *<int>*  
The integer used to round the column elements.

### Returns

The vColumn itself.

### Example

```
1 from vertica_ml_python.vdataframe import vdf_from_relation
relation = relation = "((SELECT 5.12132 AS x) UNION ALL (SELECT -1.213 AS x)
    UNION ALL (SELECT 2.12347 AS x) UNION ALL (SELECT -9.965 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
vdf["x"]
5
#Output
7           x
0      5.12132
9      -1.21300
2       2.12347
11     -9.96500
Name: x, Number of rows: 4, dtype: numeric(6,5)
13
vdf["x"].round(n = 1)
15
#Output
17           x
0      5.10000
19     -1.20000
2       2.10000
21     -10.00000
Name: x, Number of rows: 4, dtype: numeric(6,5)
```

#### 8.3.2.64 sem

```
vColumn.sem(self)
```

Returns the column unbiased standard error of the mean.

### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["fare"].std()

5 #Output
  1.49928585339507
```

#### 8.3.2.65 skewness / skew

```
vColumn.skewness(self)
```

Returns the column unbiased skewness.

### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["age"].skew()

5 #Output
  0.408876460779437
```

#### 8.3.2.66 slice

```
slice(self, length: int, unit: str = "second", start: bool = True)
```

Slice the time series.

### Parameters

- **length:** *<int>*  
Slice size.
- **unit:** *<str>*, optional  
Slice size unit.
- **start:** *<bool>*, optional  
Consider the floor of the slicing or the next one.

## Returns

The vColumn itself.

## Example

```

1 from vertica_ml_python.learn.datasets import load_smart_meters
  sm = load_smart_meters(cur)
3 sm["time"]

5 # Output

7           time
0    2014-01-01 01:15:00
9    2014-01-01 02:30:00
2    2014-01-01 03:00:00
11   2014-01-01 05:00:00
4    2014-01-01 06:00:00
13   ...
Name: time, Number of rows: 11844, dtype: timestamp

15 sm["time"].slice(length = "1", unit = "hour")

17 # Output

19           time
21 0    2014-01-01 01:00:00
  1    2014-01-01 02:00:00
23 2    2014-01-01 03:00:00
  3    2014-01-01 05:00:00
25 4    2014-01-01 06:00:00
  ...
27 Name: time, Number of rows: 11844, dtype: timestamp

```

### 8.3.2.67 std

```

1 vColumn.std(self)

```

Returns the column standard deviation.

## Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["fare"].std()

```

```

5 #Output
52.6460729831293

```

### 8.3.2.68 str\_contains

```
vColumn.str_contains(self, pat: str)
```

Verify if a regular expression is in each of the column elements. The column will be transformed.

#### Parameters

- **pat:** <str>  
The regular expression.

#### Returns

The vColumn itself.

#### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
3 titanic["name"]
4
5 #Output
6
7           name
8 0  Allison, Miss. Helen Loraine
9 1  Allison, Mr. Hudson Joshua Creighton
10 2  Allison, Mrs. Hudson J C (Bessie Wald...
11 3  Andrews, Mr. Thomas Jr
12 4  Artagaveytia, Mr. Ramon
13 ...
14 Name: name, Number of rows: 1234, dtype: varchar(164)
15
16 titanic["name"].str_contains(' ([A-Za-z]+)\.')
17
18 #Output
19
20           name
21 0      True
22 1      True
23 2      True
24 3      True
25 4      True
26 ...
27 Name: name, Number of rows: 1234, dtype: boolean

```

### 8.3.2.69 str\_count

```
1 vColumn.str_count(self, pat: str)
```

Compute the number of times a regular expression is in each of the column elements. The column will be transformed.

#### Parameters

- **pat:** <str>  
The regular expression.

#### Returns

The vColumn itself.

#### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
2 titanic = load_titanic(cur)
3 titanic["name"]
4
5 #Output
6
7           name
8 0  Allison, Miss. Helen Loraine
9 1  Allison, Mr. Hudson Joshua Creighton
10 2  Allison, Mrs. Hudson J C (Bessie Wald...
11 3  Andrews, Mr. Thomas Jr
12 4  Artagaveytia, Mr. Ramon
13 ...
14 Name: name, Number of rows: 1234, dtype: varchar(164)
15
16 titanic["name"].str_count(' ([A-Za-z]+)\.')
17
18 #Output
19
20           name
21 0           1
22 1           1
23 2           1
24 3           1
25 4           1
26 ...
27 Name: name, Number of rows: 1234, dtype: int
```

### 8.3.2.70 str\_extract

```
1 vColumn.str_extract(self, pat: str)
```

Extract the regular expression in each of the column elements. The column will be transformed.

### Parameters

- **pat:** <str>  
The regular expression.

### Returns

The vColumn itself.

### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["name"]

5 #Output
      name
7 0      Allison, Miss. Helen Loraine
  1      Allison, Mr. Hudson Joshua Creighton
9 2      Allison, Mrs. Hudson J C (Bessie Wald...
  3      Andrews, Mr. Thomas Jr
11 4      Artagaveytia, Mr. Ramon
   ...      ...
13 Name: name, Number of rows: 1234, dtype: varchar(164)

15 titanic["name"].str_extract(' ([A-Za-z]+)\.')

17 #Output
      name
19 0      Miss.
  1      Mr.
21 2      Mrs.
  3      Mr.
23 4      Mr.
   ...      ...
25 Name: name, Number of rows: 1234, dtype: varchar(164)
```

#### 8.3.2.71 str\_replace

```
1 vColumn.str_replace(self, to_replace: str, value: str = "")
```

Replace the regular expression in each of the column elements by another value. The column will be transformed.

### Parameters

- **to\_replace:** <str>  
The regular expression to replace.
- **value:** <str>, optional  
The new value.

### Returns

The vColumn itself.

### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["name"]

5 #Output
                                name
7 0                Allison, Miss. Helen Loraine
  1      Allison, Mr. Hudson Joshua Creighton
9 2 Allison, Mrs. Hudson J C (Bessie Wald...
  3                Andrews, Mr. Thomas Jr
11 4                Artagaveytia, Mr. Ramon
   ...
13 Name: name, Number of rows: 1234, dtype: varchar(164)

15 titanic["name"].str_replace(' ([A-Za-z]+)\.')

17 #Output
                                name
19 0                Allison, Helen Loraine
  1      Allison, Hudson Joshua Creighton
21 2 Allison, Hudson J C (Bessie Waldo Dan...
  3                Andrews, Thomas Jr
23 4                Artagaveytia, Ramon
   ...
25 Name: name, Number of rows: 1234, dtype: varchar(672)

```

#### 8.3.2.72 str\_slice

```

1 vColumn.str_slice(self, start: int, step: int)

```

Slice the column expression. The column will be transformed.

### Parameters

- **start:** *<int>*  
Where to start on the expression.
- **step:** *<int>*  
The step to use (output expression length).

### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["name"]

5 #Output
                                name
7 0      Allison, Miss. Helen Loraine
  1      Allison, Mr. Hudson Joshua Creighton
9 2      Allison, Mrs. Hudson J C (Bessie Wald...
  3      Andrews, Mr. Thomas Jr
11 4      Artagaveytia, Mr. Ramon
   ...      ...
13 Name: name, Number of rows: 1234, dtype: varchar(164)

15 titanic["name"].str_slice(0, 5)

17 #Output
      name
19 0      Alli
  1      Alli
21 2      Alli
  3      Andr
23 4      Art
   ...      ...
25 Name: name, Number of rows: 1234, dtype: varchar(20)

```

#### 8.3.2.73 sub

```

1 vColumn.sub(self, x: float)

```

Subtract a float from the column elements.

### Parameters



- **x:** *<float>*  
A float number.

### Returns

The vColumn itself.

### Example

```

1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "((SELECT 5 AS x) UNION ALL (SELECT -1 AS x) UNION ALL (SELECT 2 AS
    x) UNION ALL (SELECT -9 AS x)) z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")
  vdf["x"]
5
#Output
7      x
0      5
9     -1
2      2
11     -9
Name: x, Number of rows: 4, dtype: int
13
vdf["x"].sub(x = 2)
15
#Output
17      x
0      3
19     -3
2      0
21     -11
Name: x, Number of rows: 4, dtype: int

```

### 8.3.2.74 sum

```
vColumn.sum(self)
```

Returns the column sum.

### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["fare"].sum()
5
#Output

```

```
41877.3576
```

### 8.3.2.75 tail

```
vColumn.tail(self, limit: int = 5, offset: int = 0)
```

Returns a part of the column. The tail is not necessary the end of the object.

#### Parameters

- **limit:** *<int>*, optional  
The number of elements to return.
- **offset:** *<int>*, optional  
The number of elements to skip.

#### Returns

The `tablesample` type containing the tail (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to `vDataFrame` using the `to_vdf` method.

#### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["fare"].tail(limit = 4, offset = 10)

5 #Output
   fare
7 10   35.50000
  11   26.55000
9 12   30.50000
  13   50.49580
11 ...      ...
   Name: fare, Number of rows: 1234, dtype: numeric(10,5)
```

### 8.3.2.76 to\_enum

```
vColumn.to_enum(self, h: float = 0)
```

Converts the column to categorical.

#### Returns

The `vColumn` itself.

#### Parameters

- **h:** *<float>*, optional

The interval size to convert used to convert the column. If this parameter is equal to 0, an optimised interval will be computed.

### Example

```

1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["fare"]

5 #Output
      fare
7 0    151.55000
  1    151.55000
9 2    151.55000
  3      0.00000
11 4    49.50420
   ...      ...
13 Name: fare, Number of rows: 1234, dtype: numeric(10,5)

15 titanic["fare"].to_enum()

17 #Output
      fare
19 0    [141;188]
  1    [141;188]
21 2    [141;188]
  3      [0;47]
23 4    [47;94]
   ...      ...
25 Name: fare, Number of rows: 1234, dtype: varchar

```

#### 8.3.2.77 topk

```

1 vColumn.topk(self, k: int = -1, dropna: bool = True)

```

Returns the top k most occurrent column elements.

#### Parameters

- **k:** *<int>*, optional  
Number of elements to consider. If this parameter is equal to -1, all the categories will be returned.
- **dropna:** *<bool>*, optional  
Do not consider null values as a category.

## Returns

The `tablesampler` type containing the column topk categories (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to `vDataFrame` using the `to_vdf` method.

## Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["pclass"].topk()

5 #Output
      count      percent
7 3         663  53.7277147487844
  1         312  25.2836304700162
9 2         259  20.9886547811994
```

### 8.3.2.78 to\_timestamp

```
1 vColumn.to_timestamp(self)
```

Convert the column to timestamp.

## Returns

The `vColumn` itself.

## Example

```
1 from vertica_ml_python.vdataframe import vdf_from_relation
  relation = "((SELECT '2014-01-01' AS x) UNION ALL (SELECT '2014-02-09' AS x))
              z"
3 vdf = vdf_from_relation(relation, dsn = "VerticaDSN")

5 #Output
              x
7 0    2014-01-01
  1    2014-02-09
9 Name: x, Number of rows: 2, dtype: varchar(10)

11 vdf["x"].to_timestamp()

13 #Output
              x
15 0    2014-01-01 00:00:00
   1    2014-02-09 00:00:00
```

```
17 Name: x, Number of rows: 2, dtype: timestamp
```

### 8.3.2.79 value\_counts

```
1 vColumn.value_counts(self, k: int = 30)
```

Returns the top k most occurrent column elements and their respective count.

#### Parameters

- **k:** <int>, optional  
Number of elements to consider. If this parameter is equal to -1, all the categories will be returned.

#### Returns

The `tablesampl` type containing the value counts (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to `vDataFrame` using the `to_vdf` method.

#### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["pclass"].value_counts()

5 #Output
      value
7 name    "pclass"
  dtype    int
9 unique      3
  3         663
11 1         312
  2         259
```

### 8.3.2.80 var

```
vColumn.var(self)
```

Returns the column variance.

#### Example

```
1 from vertica_ml_python.learn.datasets import load_titanic
  titanic = load_titanic(cur)
3 titanic["fare"].var()
```

```
# Output
2771.60900054498
```

## 9 vertica\_ml\_python.utilities

Some functions were created to simplify the process. The object `tablesample` stores in memory a small quantity of data which correspond most of the time to a query result. These utilities functions and objects are very important to understand all the `vertica-ml-python` API.

### 9.1 Functions

#### 9.1.1 drop\_model

```
def drop_model(name: str, cursor)
```

Drop the Vertica model.

##### Parameters

- **name:** *<str>*  
Name of the model.
- **cursor:** *<object>*  
Database Cursor.

#### 9.1.2 drop\_table

```
def drop_table(name: str, cursor)
```

Drop the Vertica table.

##### Parameters

- **name:** *<str>*  
Name of the table.
- **cursor:** *<object>*  
Database Cursor.

#### 9.1.3 drop\_text\_index

```
def drop_text_index(name: str, cursor)
```

Drop the Vertica text index.

##### Parameters

- **name:** *<str>*  
Name of the text index.
- **cursor:** *<object>*  
Database Cursor.

#### 9.1.4 drop\_view

```
def drop_view(name: str, cursor)
```

Drop the Vertica view.

##### Parameters

- **name:** *<str>*  
Name of the view.
- **cursor:** *<object>*  
Database Cursor.

#### 9.1.5 load\_model

```
def load_model(name: str, cursor, test_relation: str = "")
```

Returns the model object.

##### Parameters

- **name:** *<str>*  
Model name.
- **cursor:** *<object>*  
Database Cursor.
- **test\_relation:** *<str>*, optional  
Name of the relation used to test the model. If it is not defined, the test relation will be the same as the one used to train the model.

#### 9.1.6 pandas\_to\_vertica

```
pandas_to_vertica(df, cur, name: str)
```

Store a pandas DataFrame in the Vertica DB.

##### Parameters

- **df:** *<object>*  
Pandas DataFrame.
- **cursor:** *<object>*  
Database Cursor.
- **name:** *<str>*  
Name of the table.

### 9.1.7 to\_tablesample

```
1 to_tablesample(query: str, cursor, name = "Sample")
```

Returns the tablesample of the query.

#### Parameters

- **query:** <str>  
SQL query.
- **cursor:** <object>  
Database Cursor.
- **name:** <str>, optional  
Name of the tablesample.

```
1 from vertica_ml_python.utilities import to_tablesample
  to_tablesample('SELECT age, survived FROM titanic LIMIT 5', cur)
3
4 #Output
5      age      survived
6 0    2.000           0
7 1   30.000           0
8 2   25.000           0
9 3   39.000           0
10 4   71.000           0
11 Name: Sample, Number of rows: 5, Number of columns: 2
```

### 9.1.8 vertica\_cursor

```
1 vertica_cursor(dsn: str)
```

Returns the Vertica cursor by parsing the DSN (this function will read the ODBCINI file).

#### Parameters

- **dsn:** <str>  
Database DSN.

```
1 from vertica_ml_python.utilities import vertica_cursor
  vertica_cursor("VerticaDSN").execute("SELECT age FROM titanic LIMIT 1").
    fetchall()
3
4 #Output
5 [[Decimal('2.000')]]
```



## 9.2 tablesample

The `tablesample` is the transition from 'Big Data' to 'Small Data'. This object was created to have a nice way of displaying the results and to not have any dependency to any other library. It stores the aggregated result in memory and has some useful method to transform it to `pandas.DataFrame` or `vDataFrame`.

### 9.2.1 initialization

```

1 class tablesample(
    values: dict = {}, # Dictionary of the stored columns
    dtype: dict = {}, # Dictionary of the columns types
3     name: str = "Sample") # Object Name

```

### 9.2.2 attributes

The `tablesample` has two main attributes:

- **values:** The Dictionary of the stored columns.
- **dtype:** The Dictionary of the columns types.

### 9.2.3 methods

The `tablesample` has 4 main methods:

- **transpose(self):** Transpose the `tablesample`.
- **to\_pandas(self):** Convert the `tablesample` to a `pandas.DataFrame`.
- **to\_sql(self):** Generate the sql to build the `tablesample` to the DB.
- **to\_vdf(self, cursor = None, dsn: str = ""):** Convert the `tablesample` to a `vDataFrame`.

## 10 vertica\_ml\_python.learn

This part of the API was built to apply Highly Distributed and Scalable Machine Learning directly on the data. Many algorithms are available and many metrics are very useful to evaluate precisely the efficiency and performance of the created models. Some models are built-in Vertica functions (Highly Distributed and Highly Scalable) and others are based on SQL code generation. In the different sections some of the algorithms methods parameters could be undefined because of the repetitiveness of the process. We will always use the following notations:

- **X <str>:** List of the predictors columns.
- **y or y\_true <str>:** Response column.
- **y\_score <str>:** Prediction.
- **input\_relation <str>:** Input relation used to train the model.
- **test\_relation <str>:** Relation used to test the model. If it is empty, the train relation is used as test.
- **vdf <object>:** A Virtual DataFrame.

- **method** <str>: The method to compute the score, it must be in {accuracy | auc | prc\_auc | best\_cutoff | recall | precision | log\_loss | negative\_predictive\_value | specificity | mcc | informedness | markedness | critical\_success\_index} for classification and in {r2 | mae (mean absolute error) | mse (mean squared error) | msle (mean squared log error) | max (max error) | median (median absolute error) | var (explained variance)} for regression.
- **cutoff** <float>: Prediction threshold in the case of binary classification. It must be in ]0,1[
- **pos\_label** <str or int>: Main class in the prediction (the positive class), the other classes will be seen as negative.
- **labels** <list>: Labels to consider during the computation.
- **tree\_id** <int>: The tree ID in case of multi-tree models.

All the objects will have all its parameters stored as attribute. For example, it is possible to change the test relation anytime by changing the `test_relation` attribute.

## 10.1 vertica\_ml\_python.learn.cluster

### 10.1.1 DBSCAN

Create a DBSCAN object by using the DBSCAN algorithm as defined by Martin Ester, Hans-Peter Kriegel, Jörg Sander and Xiaowei Xu. This object is using pure SQL to compute all the distances and neighbors. It is also using Python to compute the cluster propagation (non scalable phase). This model is using CROSS JOIN and may be really expensive in some cases. It will index all the elements of the table in order to be optimal (the CROSS JOIN will happen only with IDs which are integers). As DBSCAN is using the p-distance, it is highly sensible to un-normalized data. However, DBSCAN is really robust to outliers and can find non-linear clusters. It is a very powerful algorithm for outliers detection and clustering.

#### initialization

```

1 class DBSCAN(
2     name: str,
3     cursor,
4     eps: float = 0.5,
5     min_samples: int = 5,
6     p: int = 2)

```

#### Parameters

- **name:** <str>  
Name of the relation created after fitting the model.
- **cursor:** <object>  
DB cursor.
- **eps:** <float>, optional  
The radius of a neighborhood with respect to some point.
- **min\_samples:** <int>, optional  
Minimum number of points required to form a dense region.
- **p:** <int>, optional  
The p corresponding to the one of the p-distance (distance metric used during the model computation).

## Methods

The DBSCAN object has four main methods:

```

# Fit the model with the input columns
2 def fit(self, input_relation: str, X: list, key_columns: list = [], index = ""
    )

4 # Print the model information
  def info(self)

6 # Plot the model (only possible if the number of columns <= 3)
  def plot(self)

8 # Create a vDataframe using the final relation
10 def to_vdf(self)

```

The index parameter (name of the primary key column in the relation) of the 'fit' method is very important as without it an indexed copy of the main relation will be created (it could be really expensive). It is highly recommended to have a primary key column in the main table to avoid unnecessary computations.

## Attributes

The DBSCAN object has two main attributes:

```

1 self.n_cluster # Number of clusters
  self.n_noise # Number of elements considered as noise by the algorithm

```

## Example

```

from vertica_ml_python import vDataframe
2 from vertica_ml_python.learn.cluster import DBSCAN

4 # Building a normalized relation of the features, we will use
  titanic = vDataframe("titanic", cur)
6 # We will use a sample of the data in order to have a beautiful plot
  titanic.main_relation += " TABLESAMPLE(10) "
8 titanic = titanic.select(["fare", "age"])
  titanic.normalize()
10 titanic.to_db("titanic_normalize")

12 # We can build the model
  model = DBSCAN("dbscan_titanic", cur)
14 model.fit("titanic_normalize", ["fare", "age"])

16 # We can see the different information relative to the model
  model.info()

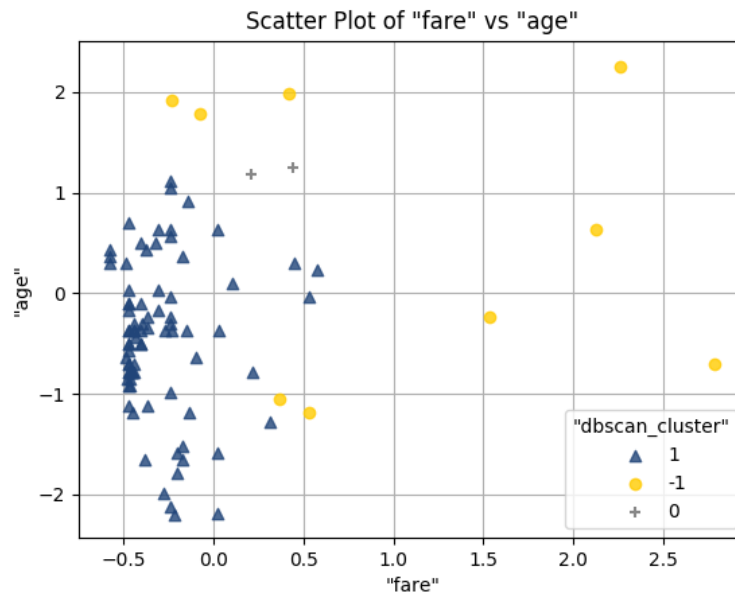
18 # Output
20 DBSCAN was successfully achieved by building 3 cluster(s) and by identifying
    21 elements as noise.

```

If you are **not** happy with the result, do **not** forget to normalize the data before applying DBSCAN. As this algorithm **is** using the p-distance, it **is** really sensible to the data distribution.

```
# And Plot the model
```

```
model.plot()
```



### 10.1.2 KMeans

Create a KMEANS object by using the Vertica Highly Distributed and Scalable KMEANS directly on the data.

#### initialization

```
class KMEANS (
    name: str,
    cursor,
    n_cluster: int = 8,
    init = "kmeanspp",
    max_iter: int = 300,
    tol: float = 1e-4)
```

#### Parameters

- **name:** *<str>*  
Name of the the model. The model is stored in the DB.
- **cursor:** *<object>*  
DB cursor.
- **n\_cluster:** *<int>*, optional  
Number of clusters.

- **init:** *<str or list>*, optional  
The method used to find the initial cluster centers. The method can be in {random | kmeanspp}. It can be also a list with the initial cluster centers to use.
- **max\_iter:** *<int>*, optional  
The maximum number of iterations the algorithm performs.
- **tol:** *<float>*, optional  
Determines whether the algorithm has converged. The algorithm is considered converged after no center has moved more than a distance of 'tol' from the previous iteration.

## Methods

The KMeans object has four main methods:

```

1 # Add the cluster prediction in a vDataframe
  def add_to_vdf(self, vdf, name: str = "")
3
  # Drop the model
5 def drop(self)
7
  # Fit the model with the input columns
  def fit(self, input_relation: str, X: list)
9
  # Plot the model (only possible if the number of columns <= 3)
11 def plot(self)

```

## Attributes

The KMEANS object has two main attributes:

```

1 self.cluster_centers # Position of the cluster centers
  self.metrics # Different metrics to evaluate the model

```

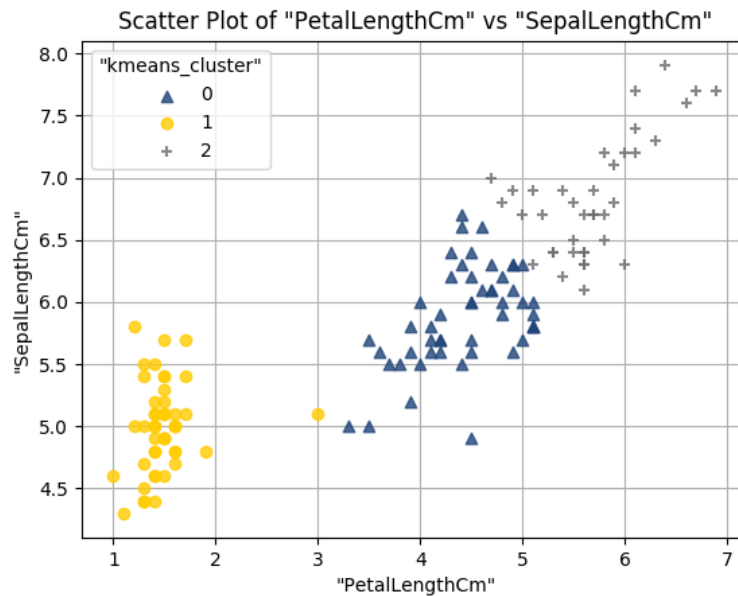
## Example

```

1 from vertica_ml_python.learn.cluster import KMeans
2
  # We can build the model
4 model = KMeans("kmeans_iris", cur, n_cluster = 3)
  model.fit("iris", ["PetalLengthCm", "SepalLengthCm"])
6
  # We can see the different metrics relative to the model
8 model.metrics
10
  # Output
12
  value
12 Between-Cluster Sum of Squares      512.23072
  Total Sum of Squares                 566.03207
14 Total Within-Cluster Sum of Squares  53.801351
  Between-Cluster SS / Total SS        0.9049499969144859
16 converged                           True

```

```
18 # And Plot the model
model.plot()
```



## 10.2 vertica\_ml\_python.learn.datasets

Many datasets are available to learn some Data Science basics or to test the API. These functions will store the data in the DB using the specific schema and table name.

### 10.2.1 load\_iris

```
load_iris(cursor, schema: str = 'public', name = 'iris')
```

Load and store the Iris Dataset (Classification, Regression and Clustering).

### 10.2.2 load\_smart\_meters

```
load_smart_meters(cursor, schema: str = 'public', name = 'iris')
```

Load and store the Iris Dataset Smart Meter Dataset (Time series and Clustering).

### 10.2.3 load\_titanic

```
load_titanic(cursor, schema: str = 'public', name = 'iris')
```

Load and store the Titanic Dataset (Classification and Regression).

### 10.2.4 load\_winequality

```
1 load_winequality(cursor, schema: str = 'public', name = 'iris')
```

Load and store the Wine Quality Dataset (Classification and Regression).

## 10.3 vertica\_ml\_python.learn.decomposition

### 10.3.1 PCA

Create a PCA object by using the Vertica Highly Distributed and Scalable PCA on the data.

#### Initialization

```
1 class PCA(
2     name: str,
3     cursor,
4     n_components: int = 0,
5     scale: bool = False,
6     method: str = "Lapack")
```

#### Parameters

- **name:** <str>  
Name of the model.
- **cursor:** <object>  
DB cursor.
- **n\_components:** <int>, optional  
The number of components to keep in the model. If this value is not provided, all components are kept. The maximum number of components is the number of non-zero singular values returned by the internal call to SVD. This number is less than or equal to SVD (number of columns, number of rows).
- **scale:** <bool>, optional  
A Boolean value that specifies whether to standardize the columns during the preparation step: If true use a correlation matrix instead of a covariance matrix.
- **method:** <str>, optional  
The method used to calculate PCA, can be set to LAPACK.

#### Methods

The PCA object has 3 methods:

```
1 # Drop the model from the DB
2 def drop(self)
3
4 # Fit the model with the input columns
5 def fit(self, input_relation: str, X: list)
6
7 # Build a vdf from the output relation
8 def to_vdf(self, n_components: int = 0, cutoff: float = 1, key_columns: list
9     = [], inverse: bool = False)
```

## Attributes

The PCA object has only 3 attributes:

```
self.components # The principal components
2 self.explained_variance # The information about singular values found.
self.mean # The information about columns from the input relation used for
    creating the PCA model
```

## Example

```
1 from vertica_ml_python.learn.decomposition import PCA

3 # We can build the model
model = PCA("pca_iris", cur)
5 model.fit("iris", ["SepalLengthCm", "SepalWidthCm", "PetalWidthCm", "
    PetalLengthCm"])

7 # We can evaluate the model
model.explained_variance

9 # Output

11         value      explained_variance  \
1      2.05544174529956      0.924616207174268  \
13     0.492182457659266      0.0530155678505349  \
15     0.280221177097938      0.0171851395250067  \
17     0.153892907978245      0.0051830854501896  \
    accumulated_explained_variance
18 1      0.924616207174268
19 2      0.977631775024804
20 3      0.99481691454981

21 # We can export the model
model.to_vdf(n_components = 2)

23 # Output

25         col1      col2
26 0      -2.68420712510395      0.326607314764391
27 1      -2.71539061563413     -0.169556847556024
28 2      -2.88981953961792     -0.137345609605025
29 3      -2.74643719730873     -0.311124315751989
30 4      -2.72859298183131      0.333924563568457
31 ...          ...          ...
Name: pca_table_iris, Number of rows: 150, Number of columns: 2
```



### 10.3.2 SVD

Create a SVD object by using the Vertica Highly Distributed and Scalable SVD on the data.

#### Initialization

```

class SVD (
2     name: str,
    cursor,
4     n_components: int = 0,
    method: str = "Lapack")

```

#### Parameters

- **name:** <str>  
Name of the model.
- **cursor:** <object>  
DB cursor.
- **n\_components:** <int>, optional  
The number of components to keep in the model. If this value is not provided, all components are kept. The maximum number of components is the number of non-zero singular values returned by the internal call to SVD. This number is less than or equal to SVD (number of columns, number of rows).
- **method:** <str>, optional  
The method used to calculate SVD, can be set to LAPACK.

#### Methods

The SVD object has 3 methods:

```

1 # Drop the model from the DB
def drop(self)
3
# Fit the model with the input columns
5 def fit(self, input_relation: str, X: list)
7
# Build a vdf from the output relation
def to_vdf(self, n_components: int = 0, cutoff: float = 1, key_columns: list
    = [], inverse: bool = False)

```

#### Attributes

The SVD object has only 2 attributes:

```

self.singular_values # The right singular vectors.
2 self.explained_variance # The information about singular values found.

```

#### Example

```

from vertica_ml_python.learn.decomposition import SVD
2
# We can build the model

```

```

4 model = SVD("svd_iris", cur)
5 model.fit("iris", ["SepalLengthCm", "SepalWidthCm", "PetalWidthCm", "
6     PetalLengthCm"])
7
8 # We can evaluate the model
9 model.explained_variance
10
11 # Output
12
13      value      explained_variance  \
14 1      95.9506675123581      0.965429688562226  \
15 2      17.7229532787505      0.0329379703572465  \
16 3       3.46929666441398      0.00126213998717665  \
17 4       1.87891236262158      0.000370201093350833  \
18
19      accumulated_explained_variance
20 1      0.965429688562226
21 2      0.998367658919472
22 3      0.999629798906649
23 4      1.0
24
25 # We can export the model
26 model.to_vdf(n_components = 2)
27
28 # Output
29
30      col1      col2
31 0      0.0616171171531346      -0.129969428300603
32 1      0.0580722976924328      -0.111371451741922
33 2      0.0567633851673065      -0.118294769303341
34 3      0.0566543139689709      -0.105607729117619
35 4      0.0612300644170471      -0.13143114177406
36 ...      ...      ...
37 Name: svd_table_iris, Number of rows: 150, Number of columns: 2

```

## 10.4 vertica\_ml\_python.learn.ensemble

### 10.4.1 RandomForestClassifier

Create a RandomForestClassifier object by using the Vertica Highly Distributed and Scalable Random Forest on the data.

#### initialization

```

1 class RandomForestClassifier(
2     name: str,
3     cursor,
4     n_estimators: int = 10,
5     max_features = "auto",
6     max_leaf_nodes: int = 1e9,
7     sample: float = 0.632,

```

```

max_depth: int = 5,
min_samples_leaf: int = 1,
min_info_gain: float = 0.0,
nbins: int = 32)

```

## Parameters

- **name:** *<str>*  
Name of the the model. The model is stored in the DB.
- **cursor:** *<object>*  
DB cursor.
- **n\_estimators:** *<int>*, optional  
The number of trees in the forest, an integer between 0 and 1000, inclusive.
- **max\_features:** *<int>*, optional  
The number of randomly chosen features from which to pick the best feature to split on a given tree node. If this parameter is equal to "auto", it will be equal to the square root of the total number of predictors.
- **max\_leaf\_nodes:** *<int>*, optional  
The maximum number of leaf nodes a tree in the forest can have, an integer between 1 and 1e9, inclusive.
- **sample:** *<float>*, optional  
The portion of the input data set that is randomly picked for training each tree, a FLOAT between 0.0 and 1.0, inclusive.
- **max\_depth:** *<int>*, optional  
The maximum depth for growing each tree, an integer between 1 and 100, inclusive.
- **min\_samples\_leaf:** *<int>*, optional  
The minimum number of samples each branch must have after splitting a node, an integer between 1 and 1e6, inclusive. A split that causes fewer remaining samples is discarded.
- **min\_info\_gain:** *<float>*, optional  
The minimum threshold for including a split, a FLOAT between 0.0 and 1.0, inclusive. A split with information gain less than this threshold is discarded.
- **nbins:** *<int>*, optional  
The number of bins to use for continuous features, an integer between 2 and 1000, inclusive.

## Methods

The RandomForestClassifier object has many methods:

```

1 # Add the RF prediction in a vDataframe
2 def add_to_vdf(self, vdf, name: str = "", cutoff: float = 0.5)
3
4 # Compute different metrics to evaluate the model
5 def classification_report(self, cutoff: float = 0.5, labels = [])
6
7 # Draw the confusion matrix of the model
8 def confusion_matrix(self, pos_label = None, cutoff: float = 0.5)
9
10 # Save a table or a view in the DB corresponding to the model predictions for
    all the classes

```

```

11 def deploy_to_DB(self, name: str, view: bool = True, cutoff = -1, all_classes:
    bool = False)

13 # Drop the model from the DB
    def drop(self)

15
    # Export the selected tree to the graphviz format
17 def export_graphviz(self, tree_id: int = 0)

19 # Compute and plot the feature importance
    def features_importance(self)

21
    # Fit the model with the input columns
23 def fit(self, input_relation: str, X: list, y: str, test_relation: str = "")

25 # Returns a tablesample of the selected tree
    def get_tree(self, tree_id: int = 0)

27
    # Draw the Lift Chart
29 def lift_chart(self, pos_label = None)

31 # Plot the selected tree
    def plot_tree(self, tree_id: int = 0, pic_path: str = "")

33
    # Draw the PRC Curve
35 def prc_curve(self, pos_label = None)

37 # Draw the ROC Curve
    def roc_curve(self, pos_label = None)

39
    # Compute the selected metric
41 def score(self, pos_label = None, cutoff: float = 0.5, method: str = "accuracy
    ")

```

### Attributes

The RandomForestClassifier object has only one attribute:

```

1 self.classes # The response column classes

```

### Example

```

1 from vertica_ml_python.learn.ensemble import RandomForestClassifier

3 # We can build the model
    model = RandomForestClassifier("rf_iris", cur, max_depth = 3, n_estimators =
        20)
5 model.fit("iris", ["PetalLengthCm", "SepalLengthCm", "SepalWidthCm"], "Species
    ")

```

```

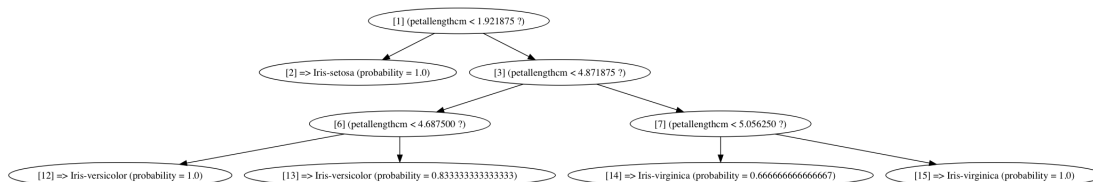
7 # We can look at the model confusion matrix
model.confusion_matrix()

9
# Output
11
      Iris-setosa  Iris-versicolor  Iris-virginica
Iris-setosa      50                0                0
13 Iris-versicolor  0                46                4
Iris-virginica   0                3                47

15
# We can also plot the first tree
17 model.plot_tree(pic_path = "tree0.png")

19 # Output
[1] (petallengthcm < 1.921875 ?)
21 |-- [2] => Iris-setosa (probability = 1.0)
|-- [3] (petallengthcm < 4.871875 ?)
23   |-- [6] (petallengthcm < 4.687500 ?)
   |   |-- [12] => Iris-versicolor (probability = 1.0)
25   |   |-- [13] => Iris-versicolor (probability = 0.8333333333333333)
   |-- [7] (petallengthcm < 5.056250 ?)
27     |-- [14] => Iris-virginica (probability = 0.6666666666666667)
     |-- [15] => Iris-virginica (probability = 1.0)

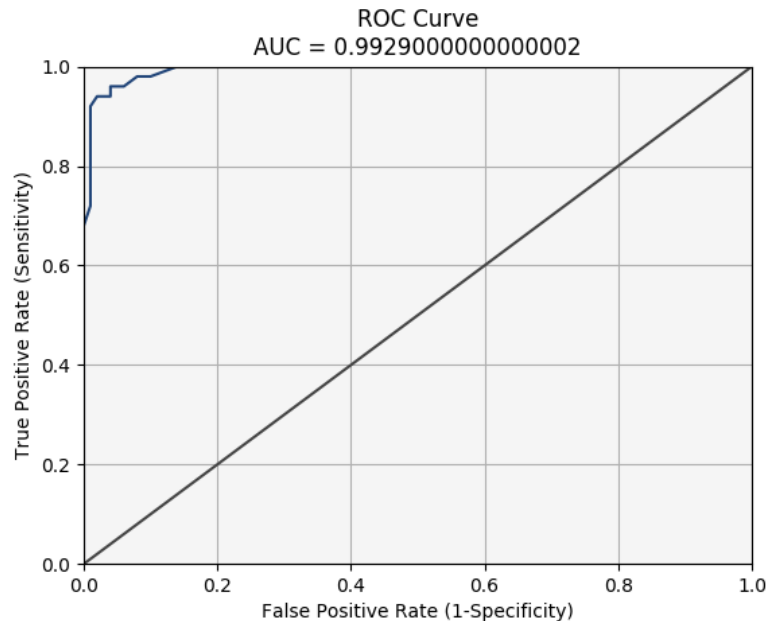
```



```

# We can also look at the Iris-virginica ROC curve
2 model.roc_curve(pos_label = 'Iris-virginica')

```



#### 10.4.2 RandomForestRegressor

Create a RandomForestRegressor object by using the Vertica Highly Distributed and Scalable Random Forest on the data.

##### initialization

```

class RandomForestRegressor (
2     name: str,
    cursor,
4     n_estimators: int = 10,
    max_features = "auto",
6     max_leaf_nodes: int = 1e9,
    sample: float = 0.632,
8     max_depth: int = 5,
    min_samples_leaf: int = 1,
10    min_info_gain: float = 0.0,
    nbins: int = 32)

```

##### Parameters

- **name:** <str>  
Name of the the model. The model is stored in the DB.
- **cursor:** <object>  
DB cursor.
- **n\_estimators:** <int>, optional  
The number of trees in the forest, an integer between 0 and 1000, inclusive.
- **max\_features:** <int>, optional  
The number of randomly chosen features from which to pick the best feature to split on a given tree node. If this parameter is equal to "auto", it will be equal to the square root of the total number of predictors

- **max\_leaf\_nodes:** *<int>*, optional  
The maximum number of leaf nodes a tree in the forest can have, an integer between 1 and 1e9, inclusive.
- **sample:** *<float>*, optional  
The portion of the input data set that is randomly picked for training each tree, a FLOAT between 0.0 and 1.0, inclusive.
- **max\_depth:** *<int>*, optional  
The maximum depth for growing each tree, an integer between 1 and 100, inclusive.
- **min\_samples\_leaf:** *<int>*, optional  
The minimum number of samples each branch must have after splitting a node, an integer between 1 and 1e6, inclusive. A split that causes fewer remaining samples is discarded.
- **min\_info\_gain:** *<float>*, optional  
The minimum threshold for including a split, a FLOAT between 0.0 and 1.0, inclusive. A split with information gain less than this threshold is discarded.
- **nbins:** *<int>*, optional  
The number of bins to use for continuous features, an integer between 2 and 1000, inclusive.

## Methods

The RandomForestRegressor object has many methods:

```

1 # Add the RF prediction in a vDataFrame
2 def add_to_vdf(self, vdf, name: str = "")
3
4 # Save a table or a view in the DB corresponding to the model predictions for
   all the classes
5 def deploy_to_DB(self, name: str, view: bool = True)
6
7 # Drop the model from the DB
8 def drop(self)
9
10 # Export the selected tree to the graphviz format
11 def export_graphviz(self, tree_id: int = 0)
12
13 # Compute and plot the feature importance
14 def features_importance(self)
15
16 # Fit the model with the input columns
17 def fit(self, input_relation: str, X: list, y: str, test_relation: str = "")
18
19 # Returns a table sample of the selected tree
20 def get_tree(self, tree_id: int = 0)
21
22 # Plot the selected tree
23 def plot_tree(self, tree_id: int = 0, pic_path: str = "")
24
25 # Evaluate the test relation by computing many different metrics
26 def regression_report(self)
27

```

```
# Compute the selected metric
29 def score(self, method: str = "r2")
```

### Example

```
1 from vertica_ml_python.learn.ensemble import RandomForestRegressor

3 # We can build the model
model = RandomForestRegressor("rf_iris", cur, max_depth = 3, n_estimators =
    20)
5 model.fit("iris", ["PetalLengthCm", "SepalWidthCm", "Species"], "SepalLengthCm
    ")

7 # We can evaluate the model
model.regression_report()

9 # Output
11 explained_variance          0.855205647780937
max_error                    0.995783115048306
13 median_absolute_error      0.207286172097297
mean_absolute_error          0.24878157077602
15 mean_squared_error          0.0988507117473723
r2                            0.85487081683392

17 # We can also get the graphviz format of the trees
19 model.export_graphviz()

21 # Output
digraph Tree{
23 1 [label = "petallengthcm < 4.134375 ?", color="blue"];
  1 -> 2 [label = "yes", color = "black"];
25 1 -> 3 [label = "no", color = "black"];
  2 [label = "petallengthcm < 3.396875 ?", color="blue"];
27 2 -> 4 [label = "yes", color = "black"];
  2 -> 5 [label = "no", color = "black"];
29 4 [label = "petallengthcm < 1.368750 ?", color="blue"];
  4 -> 8 [label = "yes", color = "black"];
31 4 -> 9 [label = "no", color = "black"];
  8 [label = "prediction: 4.600000, variance: 0", color="red"];
33 9 [label = "prediction: 5.014706, variance: 0.0994896", color="red"];
  5 [label = "sepalwidthcm < 2.225000 ?", color="blue"];
35 5 -> 10 [label = "yes", color = "black"];
  5 -> 11 [label = "no", color = "black"];
37 10 [label = "prediction: 6.000000, variance: 0", color="red"];
  11 [label = "prediction: 5.622222, variance: 0.0150617", color="red"];
39 3 [label = "sepalwidthcm < 3.425000 ?", color="blue"];
  3 -> 6 [label = "yes", color = "black"];
41 3 -> 7 [label = "no", color = "black"];
```



```

6 [label = "petallengthcm < 5.609375 ?", color="blue"];
43 6 -> 12 [label = "yes", color = "black"];
6 -> 13 [label = "no", color = "black"];
45 12 [label = "prediction: 6.164706, variance: 0.225813", color="red"];
13 [label = "prediction: 7.175000, variance: 0.189375", color="red"];
47 7 [label = "sepalwidthcm < 3.650000 ?", color="blue"];
7 -> 14 [label = "yes", color = "black"];
49 7 -> 15 [label = "no", color = "black"];
14 [label = "prediction: 7.200000, variance: 0", color="red"];
51 15 [label = "prediction: 7.900000, variance: 7.10543e-15", color="red"];
}

```

## 10.5 vertica\_ml\_python.learn.linear\_model

### 10.5.1 LinearRegression

Create a ElasticNet object by using the Vertica Highly Distributed and Scalable Linear Regression on the data. The Linear Regression is the ElasticNet model without regularization. The other parameters stay the same.

#### initialization

```

def LinearRegression(
2     name: str,
        cursor,
4     tol: float = 1e-4,
        C: float = 1.0,
6     max_iter: int = 100,
        solver: str = 'Newton')

```

### 10.5.2 ElasticNet

Create a ElasticNet object by using the Vertica Highly Distributed and Scalable Linear Regression on the data.

#### initialization

```

1 class ElasticNet(
        name: str,
3     cursor,
        penalty: str = 'ENet',
5     tol: float = 1e-4,
        C: float = 1.0,
7     max_iter: int = 100,
        solver: str = 'CGD',
9     l1_ratio: float = 0.5)

```

#### Parameters

- **name:** <str>  
Name of the model.

- **cursor:** *<object>*  
DB cursor.
- **penalty:** *<str>*, optional  
Determines the method of regularization: {None | L1 | L2 | ENet}
- **tol:** *<float>*, optional  
Determines whether the algorithm has reached the specified accuracy result.
- **C:** *<float>*, optional  
The regularization parameter value. The value must be zero or non-negative.
- **max\_iter:** *<int>*, optional  
Determines the maximum number of iterations the algorithm performs before achieving the specified accuracy result.
- **solver:** *<int>*, optional  
The optimizer method used to train the model: {Newton | BFGS | CGD}
- **l1\_ratio:** *<float>*, optional  
ENet mixture parameter that defines how much L1 versus L2 regularization to provide.

## Methods

The ElasticNet object has many methods:

```

1 # Add the ElasticNet prediction in a vDataframe
  def add_to_vdf(self, vdf, name: str = "")
3
  # Save a table or a view in the DB corresponding to the model predictions for
    all the classes
5 def deploy_to_DB(self, name: str, view: bool = True, cutoff = -1)
7
  # Drop the model from the DB
  def drop(self)
9
  # Compute the importance of each feature
11 def features_importance(self)
13
  # Fit the model with the input columns
  def fit(self, input_relation: str, X: list, y: str, test_relation: str = "")
15
  # Plot the SVM if it is possible (The length of X must be lesser of equal to
    3)
17 def plot(self)
19
  # Compute different metrics to evaluate the model
  def regression_report(self)
21
  # Compute the selected metric
23 def score(self, method: str = "r2")

```

## Attributes

The ElasticNet object has only one attribute:

```
1 self.coef # Informations about the model coefficients
```

## Example

```
1 from vertica_ml_python.learn.linear_model import ElasticNet

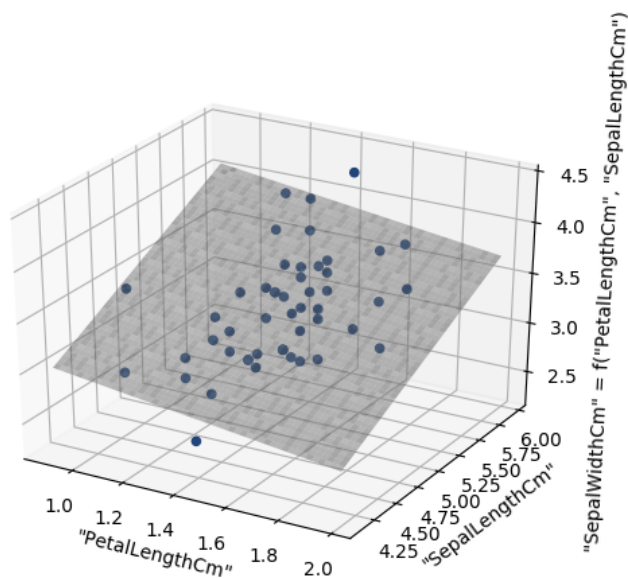
3 # We can build the model
  model = ElasticNet("enet_iris", cur, penalty = "None", tol = 1e-8)
5 model.fit("iris", ["PetalLengthCm", "SepalLengthCm"], "SepalWidthCm")

7 # We can evaluate the model
  model.regression_report()

9 # Output

11                                     value
13 explained_variance                0.452452439026576
13 max_error                        0.861565208032992
13 median_absolute_error            0.203743266177453
15 mean_absolute_error              0.251888470089032
15 mean_squared_error               0.102254872043582
17 r2                              0.452452439026074

19 # We can also draw the model
  model.plot()
```



### 10.5.3 Lasso

Create a ElasticNet object by using the Vertica Highly Distributed and Scalable Linear Regression on the data. The Lasso Regression is the ElasticNet model with the L1 regularization. The other parameters stay the same.

#### initialization

```
def Lasso(  
2     name: str,  
     cursor,  
4     tol: float = 1e-4,  
     max_iter: int = 100,  
6     solver: str = 'CGD')
```

### 10.5.4 LogisticRegression

Create a LogisticRegression object by using the Vertica Highly Distributed and Scalable Logistic Regression on the data.

#### initialization

```
class LogisticRegression(  
2     name: str,  
     cursor,  
4     penalty: str = 'L2',  
     tol: float = 1e-4,  
6     C: int = 1,  
     max_iter: int = 100,  
8     solver: str = 'CGD',  
     l1_ratio: float = 0.5)
```

- **name:** <str>  
Name of the model.
- **cursor:** <object>  
DB cursor.
- **penalty:** <str>, optional  
Determines the method of regularization: {None | L1 | L2 | ENet}
- **tol:** <float>, optional  
Determines whether the algorithm has reached the specified accuracy result.
- **C:** <int>, optional  
The regularization parameter value. The value must be zero or non-negative.
- **max\_iter:** <int>, optional  
Determines the maximum number of iterations the algorithm performs before achieving the specified accuracy result.
- **solver:** <int>, optional  
The optimizer method used to train the model: {Newton | BFGS | CGD}
- **l1\_ratio:** <float>, optional  
ENet mixture parameter that defines how much L1 versus L2 regularization to provide.

## Methods

The LogisticRegression object has many methods:

```

1 # Add the LogisticRegression prediction in a vDataframe
  def add_to_vdf(self, vdf, name: str = "", cutoff: float = 0.5)
3
  # Compute different metrics to evaluate the model
5  def classification_report(self, cutoff: float = 0.5)
7
  # Draw the confusion matrix of the model
  def confusion_matrix(self, cutoff: float = 0.5)
9
  # Save a table or a view in the DB corresponding to the model predictions for
    all the classes
11  def deploy_to_DB(self, name: str, view: bool = True, cutoff = -1)
13
  # Drop the model from the DB
  def drop(self)
15
  # Compute the importance of each feature
17  def features_importance(self)
19
  # Fit the model with the input columns
  def fit(self, input_relation: str, X: list, y: str, test_relation: str = "")
21
  # Draw the Lift Chart
23  def lift_chart(self)
25
  # Plot the LogisticRegression if it is possible (The length of X must be
    lesser or equal to 2)
  def plot(self)
27
  # Draw the PRC Curve
29  def prc_curve(self)
31
  # Draw the ROC Curve
  def roc_curve(self)
33
  # Compute the selected metric
35  def score(self, cutoff: float = 0.5, method: str = "accuracy")

```

## Attributes

The LogisticRegression object has only one attribute:

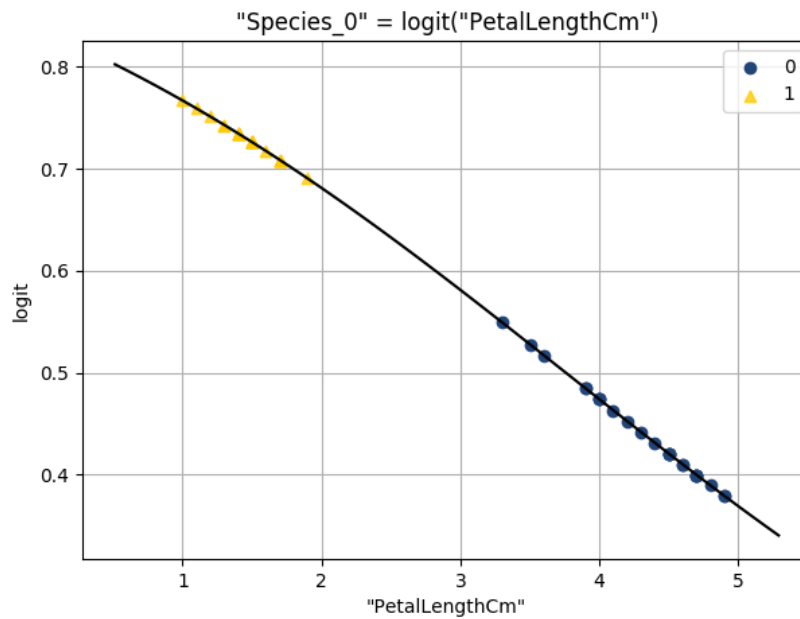
```

1 self.coef # Informations about the model coefficients

```

## Example

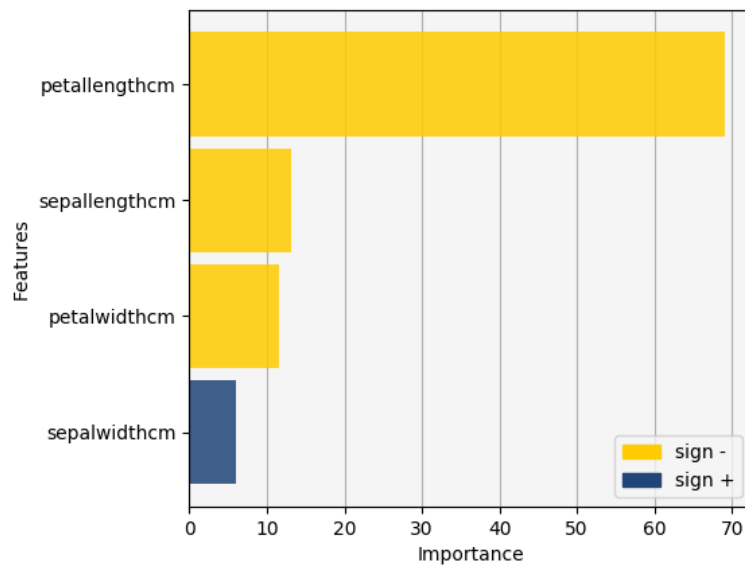
```
1 from vertica_ml_python import vDataframe
2 from vertica_ml_python.learn.linear_model import LogisticRegression
3
4 # We create dummies
5 iris = vDataframe("iris", cur)
6 iris["Species"].get_dummies(use_numbers_as_suffix = True)
7 iris.to_db("iris_dummy")
8
9 # We can build the model
10 model = LogisticRegression("logit_iris", cur)
11 model.fit("iris_dummy", ["PetalLengthCm"], "Species_0")
12
13 # We can evaluate the model
14 model.classification_report()
15
16 # Output
17
18                                     value
19 auc                                     1.0
20 prc_auc                               0.9800000000000001
21 accuracy                             0.9533333333333333
22 log_loss                             0.187846851053108
23 precision                             1.0
24 recall                               0.8771929824561403
25 f1-score                             0.9345794392523363
26 mcc                                  0.9032106474595007
27 informedness                         0.8771929824561404
28 markedness                           0.9300000000000002
29 csi                                  0.8771929824561403
30
31 # We can also draw the model
32 model.plot()
```



```

1 # We can build a new model
  model.drop()
3 model.fit("iris_dummy", ["PetalLengthCm", "PetalWidthCm", "SepalLengthCm", "
    SepalWidthCm"], "Species_0")
5 # We can see the features importance
  model.features_importance()

```



### 10.5.5 Ridge

Create a ElasticNet object by using the Vertica Highly Distributed and Scalable Linear Regression on the data. The Lasso Regression is the ElasticNet model with the L2 regularization. The other parameters stay the same.

#### initialization

```
def Ridge(  
2     name: str,  
     cursor,  
4     tol: float = 1e-4,  
     max_iter: int = 100,  
6     solver: str = 'Newton')
```

## 10.6 vertica\_ml\_python.learn.metrics

Many metrics are available to evaluate a model efficiency. These functions can be used independently of the models. For more flexibility, the input columns can also be SQL expressions.

### 10.6.1 Regression

#### 10.6.1.1 explained\_variance

```
def explained_variance(  
2     y_true: str,  
     y_score: str,  
4     input_relation: str,  
     cursor)
```

Compute the explain variance of 2 input columns.

#### 10.6.1.2 max\_error

```
1 def max_error(  
     y_true: str,  
3     y_score: str,  
     input_relation: str,  
5     cursor)
```

Compute the max error of 2 input columns.

#### 10.6.1.3 median\_absolute\_error

```
1 def median_absolute_error(  
     y_true: str,  
3     y_score: str,  
     input_relation: str,
```



```
5 cursor)
```

Compute the median absolute error of 2 input columns.

#### 10.6.1.4 mean\_absolute\_error

```
1 def mean_absolute_error(  
    y_true: str,  
3    y_score: str,  
    input_relation: str,  
5    cursor)
```

Compute the mean absolute error of 2 input columns.

#### 10.6.1.5 mean\_squared\_error

```
1 def mean_squared_error(  
    y_true: str,  
3    y_score: str,  
    input_relation: str,  
5    cursor)
```

Compute the mean squared error of 2 input columns.

#### 10.6.1.6 mean\_squared\_log\_error

```
1 def mean_squared_log_error(  
    y_true: str,  
3    y_score: str,  
    input_relation: str,  
5    cursor)
```

Compute the mean squared log error of 2 input columns.

#### 10.6.1.7 regression\_report

```
1 def regression_report(  
    y_true: str,  
3    y_score: str,  
    input_relation: str,  
5    cursor)
```

Compute different regression metrics of 2 input columns.

### 10.6.1.8 r2\_score

```
1 def r2_score(  
    y_true: str,  
3    y_score: str,  
    input_relation: str,  
5    cursor)
```

Compute the r2 score of 2 input columns.

## 10.6.2 Classification

### 10.6.2.1 accuracy\_score

```
1 def accuracy_score(  
    y_true: str,  
3    y_score: str,  
    input_relation: str,  
5    cursor)
```

Compute the accuracy of 2 input columns.

### 10.6.2.2 auc

```
1 auc(  
    y_true: str,  
3    y_score: str,  
    input_relation: str,  
5    cursor,  
    pos_label = 1)
```

Compute the AUC (Area Under the ROC) of 2 input columns.

### 10.6.2.3 classification\_report

```
classification_report(  
2    y_true: str = "",  
    y_score: str = "",  
4    input_relation: str = "",  
    cursor = None,  
6    labels: list = [],  
    cutoff: float = 0.5)
```

Compute different classification metrics of 2 input columns.

#### 10.6.2.4 confusion\_matrix

```
1 confusion_matrix(  
    y_true: str,  
3    y_score: str,  
    input_relation: str,  
5    cursor,  
    pos_label = 1)
```

Compute the Confusion Matrix of 2 input columns.

#### 10.6.2.5 critical\_success\_index

```
critical_success_index(  
2    y_true: str,  
    y_score: str,  
4    input_relation: str,  
    cursor,  
6    pos_label = 1)
```

Compute the Critical Success Index of 2 input columns.

#### 10.6.2.6 f1\_score

```
f1_score(  
2    y_true: str,  
    y_score: str,  
4    input_relation: str,  
    cursor,  
6    pos_label = 1)
```

Compute the F1 Score of 2 input columns.

#### 10.6.2.7 informedness

```
informedness(  
2    y_true: str,  
    y_score: str,  
4    input_relation: str,  
    cursor,  
6    pos_label = 1)
```

Compute the Informedness of 2 input columns.

#### 10.6.2.8 log\_loss

```
log_loss(  
2     y_true: str,  
     y_score: str,  
4     input_relation: str,  
     cursor,  
6     pos_label = 1)
```

Compute the Log Loss of 2 input columns.

#### 10.6.2.9 markedness

```
log_loss(  
2     y_true: str,  
     y_score: str,  
4     input_relation: str,  
     cursor,  
6     pos_label = 1)
```

Compute the Markedness of 2 input columns.

#### 10.6.2.10 matthews\_corrcoef

```
matthews_corrcoef(  
2     y_true: str,  
     y_score: str,  
4     input_relation: str,  
     cursor,  
6     pos_label = 1)
```

Compute the Matthews Correlation Coefficient of 2 input columns.

#### 10.6.2.11 multilabel\_confusion\_matrix

```
multilabel_confusion_matrix(  
2     y_true: str,  
     y_score: str,  
4     input_relation: str,  
     cursor,  
6     labels: list)
```

Compute the Confusion Matrix of 2 input columns in case of Multi Classification.

#### 10.6.2.12 negative\_predictive\_score

```
negative_predictive_score(  
2     y_true: str,  
     y_score: str,  
4     input_relation: str,  
     cursor,  
6     pos_label = 1)
```

Compute the Negative Predictive Score of 2 input columns.

#### 10.6.2.13 prc\_auc

```
prc_auc(  
2     y_true: str,  
     y_score: str,  
4     input_relation: str,  
     cursor,  
6     pos_label = 1)
```

Compute the PRC AUC of 2 input columns.

#### 10.6.2.14 precision\_score

```
precision_score(  
2     y_true: str,  
     y_score: str,  
4     input_relation: str,  
     cursor,  
6     pos_label = 1)
```

Compute the Precision Score of 2 input columns.

#### 10.6.2.15 recall\_score

```
recall_score(  
2     y_true: str,  
     y_score: str,  
4     input_relation: str,  
     cursor,  
6     pos_label = 1)
```

Compute the Recall Score of 2 input columns.

### 10.6.2.16 specificity\_score

```

specificity_score(
2     y_true: str,
      y_score: str,
4     input_relation: str,
      cursor,
6     pos_label = 1)

```

Compute the Specificity Score of 2 input columns.

## 10.7 vertica\_ml\_python.learn.model\_selection

### 10.7.1 best\_k

```

def best_k(
2     X: list,
      input_relation: str,
4     cursor,
      n_cluster = (1, 100),
6     init = "kmeanspp",
      max_iter: int = 50,
8     tol: float = 1e-4,
      elbow_score_stop = 0.8)

```

Find the KMeans K by using a score threshold.

#### Parameters

- **X:** *<list>*  
List of the predictor columns.
- **input\_relation:** *<str>*  
Relation used to train the model.
- **cursor:** *<object>*  
DB cursor.
- **n\_cluster:** *<tuple>*, optional  
Tuple representing the number of cluster to start with and to end with.
- **init:** *<str or list>*, optional  
The method used to find the initial cluster centers. The method can be in {random | kmeanspp}. It can be also a list with the initial cluster centers to use.
- **max\_iter:** *<int>*, optional  
The maximum number of iterations the algorithm performs.
- **tol:** *<float>*, optional  
Determines whether the algorithm has converged. The algorithm is considered converged after no center has moved more than a distance of 'tol' from the previous iteration.

- **elbow\_score\_stop:** *<float>*, optional  
Stop the Parameters Search when this Elbow score is reached.

### Example

```

1 from vertica_ml_python.learn.model_selection import best_k
3 best_k(["PetalLengthCm", "PetalWidthCm", "SepalLengthCm", "SepalWidthCm"], "
    iris", cur)
5 # Output
3

```

## 10.7.2 cross\_validate

Compute the K-Fold cross validation of an estimator.

### Initialization

```

def cross_validate(
2     estimator,
    input_relation: str,
4     X: list,
    y: str,
6     cv: int = 3,
    pos_label = None,
8     cutoff: float = 0.5)

```

### Parameters

- **estimator:** *<object>*  
Estimator having a fit method and a DB cursor.
- **input\_relation:** *<str>*  
The relation used to test the estimator.
- **X:** *<list>*  
List of the predictor columns.
- **y:** *<str>*  
Response Column.
- **cv:** *<int>*, optional  
Number of folds.
- **pos\_label:** *<anytype>*, optional  
The main class in case of classification.
- **cutoff:** *<float>*, optional  
The cutoff in case of classification. It must be in ]0,1[

## Returns

The `tables` sample type containing different metric to evaluate the estimator (the information will be stored in the `values` attribute). You can convert this object to pandas using the `to_pandas` method or to `vDataFrame` using the `to_vdf` method.

## Example

```

from vertica_ml_python.learn.linear_model import LogisticRegression
from vertica_ml_python.learn.model_selection import cross_validate

# We test the estimator
model = LogisticRegression("logit_titanic", cur)
cross_validate(model, "titanic", ["age", "pclass", "fare"], "survived")

# Output

```

	auc	prc_auc	\\
1-fold	0.7269061583577717	0.636432596278644	\\
2-fold	0.6903612550943709	0.580010812173139	\\
3-fold	0.6922692837465568	0.5612045504938292	\\
avg	0.703178899066	0.592549319649	\\
std	0.0167957786056	0.0319658708149	\\
	accuracy	log_loss	\\
1-fold	0.704663212435233	0.277918039898239	\\
2-fold	0.708433734939759	0.280386273274253	\\
3-fold	0.690531177829099	0.282475484333873	\\
avg	0.701209375068	0.280259932502	\\
std	0.00770593417198	0.00186271243782	\\
	precision	recall	\\
1-fold	0.5984848484848485	0.6528925619834711	\\
2-fold	0.47244094488188976	0.625	\\
3-fold	0.49242424242424243	0.5909090909090909	\\
avg	0.521116678597	0.622933884298	\\
std	0.0553124960506	0.0253467854264	\\
	f1-score	mcc	\\
1-fold	0.6897262557977386	0.37822641657012745	\\
2-fold	0.6642216788916055	0.31190453116529854	\\
3-fold	0.6503716409376787	0.3006795875598417	\\
avg	0.668106525209	0.330270178432	\\
std	0.0162996002176	0.0342184202053	\\
	informedness	markedness	\\
1-fold	0.38385702898854723	0.37267839687194515	\\
2-fold	0.33369565217391317	0.29153642226882437	\\
3-fold	0.31404958677685957	0.28787878787878785	\\
avg	0.343867422646	0.317364535673	\\
std	0.0293923848748	0.0391412996111	\\
	csi		
1-fold	0.4540229885057471		
2-fold	0.36809815950920244		



```

42 3-fold          0.3672316384180791
    avg           0.396450928811
44 std           0.0407111308106

```

### 10.7.3 train\_test\_split

```
train_test_split(input_relation: str, cursor, test_size: float = 0.33)
```

Build one table and 2 views which can be used to evaluate a model. The table will include all the main relation information with a test column (boolean) which represents if the data belong to the test or train set.

#### Parameters

- **input\_relation:** *<str>*  
The relation used to test the estimator.
- **cursor:** *<object>*  
A DB cursor.
- **test\_size:** *<float>*  
Proportion of the test set comparint to the training set.

#### Returns

A tuple (name of the train view, name of the test view)

## 10.8 vertica\_ml\_python.learn.naive\_bayes

### 10.8.1 MultinomialNB

Create a MultinomialNB object by using the Vertica Highly Distributed and Scalable Naive Bayes on the data.

#### initialization

```
class MultinomialNB(name: str, cursor, alpha: float = 1.0)
```

#### Parameters

- **name:** *<str>*  
Name of the the model. The model is stored in the DB.
- **cursor:** *<object>*  
DB cursor.
- **alpha:** *<float>*, optional  
A float that specifies use of Laplace smoothing if the event model is categorical, multinomial, or Bernoulli.

#### Methods

The MultinomialNB object has many methods:

```

1 # Add the MultinomialNB prediction in a vDataFrame
  def add_to_vdf(self, vdf, name: str = "", cutoff: float = 0.5)

3

  # Compute different metrics to evaluate the model
5  def classification_report(self, cutoff: float = 0.5, labels = [])

7

  # Draw the confusion matrix of the model
  def confusion_matrix(self, pos_label = None, cutoff: float = 0.5)

9

  # Save a table or a view in the DB corresponding to the model predictions for
    all the classes
11  def deploy_to_DB(self, name: str, view: bool = True, cutoff = -1, all_classes:
    bool = False )

13

  # Drop the model from the DB
  def drop(self)

15

  # Fit the model with the input columns
17  def fit(self, input_relation: str, X: list, y: str, test_relation: str = "")

19

  # Draw the Lift Chart
  def lift_chart(self, pos_label = None)

21

  # Draw the PRC Curve
23  def prc_curve(self, pos_label = None)

25

  # Draw the ROC Curve
  def roc_curve(self, pos_label = None)

27

  # Compute the selected metric
29  def score(self, pos_label = None, cutoff: float = 0.5, method: str = "accuracy
    ")

```

### Attributes

The MultinomialNB object has only one attribute:

```

1 self.classes # The response column classes

```

### Example

```

1 from vertica_ml_python.learn.naive_bayes import MultinomialNB

3 # We can build the model
  model = MultinomialNB("nb_titanic", cur)
5 model.fit("titanic", ["age", "pclass", "fare"], "survived")

7 # We can evaluate the model efficiency

```

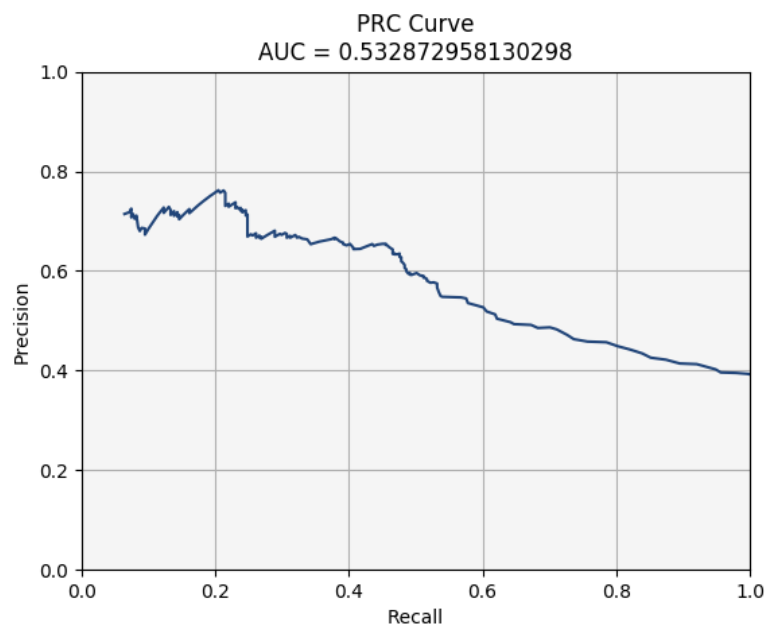
```

model.classification_report()

# Output
value
auc          0.6682737629726706
prc_auc      0.5326937341539878
accuracy     0.53484602917342
log_loss     0.586771724006015
precision    0.20460358056265984
recall       0.7619047619047619
f1-score     0.7020729308518686
mcc          0.25963840041342523
informedness 0.41285874619207963
markedness   0.16328126651307318
csi          0.19230769230769232

# We can also plot the PRC curve
model.prc_curve()

```



## 10.9 vertica\_ml\_python.learn.neighbors

### 10.9.1 KNeighborsClassifier

Create a `KNeighborsClassifier` object by using the K Nearest Neighbors Algorithm. This object is using pure SQL to compute all the distances and final score. It is using CROSS JOIN and may be really expensive in some cases. As `KNeighborsClassifier` is using the p-distance, it is highly sensible to un-normalized data.

#### initialization

```

1 class KNeighborsClassifier(
    name: str,
3     cursor,
    n_neighbors: int = 20,
5     p: int = 2)

```

## Parameters

- **name:** <str>  
Name of the relation created after fitting the model.
- **cursor:** <object>  
DB cursor.
- **n\_neighbors:** <int>, optional  
Number of neighbors.
- **p:** <int>, optional  
The p corresponding to the one of the p-distance (distance metric used during the model computation).

## Methods

The KNeighborsClassifier object has many methods:

```

1 # Compute different metrics to evaluate the model
def classification_report(self, cutoff: float = 0.5, labels = [])
3
4 # Draw the confusion matrix of the model
5 def confusion_matrix(self, pos_label = None, cutoff: float = 0.5)
6
7 # Save a table or a view in the DB corresponding to the model predictions for
  all the classes
8 def deploy_to_DB(self, name: str, view: bool = True, cutoff = -1, all_classes:
  bool = False)
9
10 # Fit the model with the input columns
11 def fit(self, input_relation: str, X: list, y: str, test_relation: str = "")
12
13 # Draw the Lift Chart
14 def lift_chart(self, pos_label = None)
15
16 # Draw the PRC Curve
17 def prc_curve(self, pos_label = None)
18
19 # Draw the ROC Curve
20 def roc_curve(self, pos_label = None)
21
22 # Compute the selected metric
23 def score(self, pos_label = None, cutoff: float = 0.5, method: str = "accuracy
  ")

```

### Example

```

1 from vertica_ml_python.learn.neighbors import KNeighborsClassifier
3
3 # We can build the model
model = KNeighborsClassifier(cur)
5 model.fit("iris", ["SepalLengthCm", "SepalWidthCm"], "Species")
7
7 # We can evaluate the model
model.classification_report()
9
9 # Output
11
11          Iris-setosa      Iris-versicolor  \\
auc          0.99      0.7909756097560976  \\
13 prc_auc      0.019615384615384597      0.6462689689983612  \\
accuracy      0.980769230769231      0.725274725274725  \\
15 log_loss      0.0171690390452333      0.233867972918641  \\
precision      0.98          0.86  \\
17 recall      1.0      0.7049180327868853  \\
f1-score      0.8      0.734496843668771  \\
19 mcc      0.8082903768654761      0.44556218017702653  \\
informedness      0.6666666666666665      0.47158469945355197  \\
21 markedness      0.98      0.4209756097560975  \\
csi          0.98      0.6323529411764706  \\
23
23          Iris-virginica
auc          0.79725
25 prc_auc      0.6555011655011654
accuracy      0.7333333333333333
27 log_loss      0.230656742114622
precision      0.66
29 recall      0.825
f1-score      0.7333333333333334
31 mcc          0.485
informedness      0.4849999999999999
33 markedness      0.4849999999999999
csi          0.5789473684210527

```

### 10.9.2 KNeighborsRegressor

Create a KNeighborsRegressor object by using the K Nearest Neighbors Algorithm. This object is using pure SQL to compute all the distances and final score. It is using CROSS JOIN and may be really expensive in some cases. As KNeighborsRegressor is using the p-distance, it is highly sensible to un-normalized data.

#### initialization

```

class KNeighborsRegressor(
2     name: str,
        cursor,
4     n_neighbors: int = 20,

```

```
p: int = 2)
```

## Parameters

- **name:** *<str>*  
Name of the relation created after fitting the model.
- **cursor:** *<object>*  
DB cursor.
- **n\_neighbors:** *<int>*, optional  
Number of neighbors.
- **p:** *<int>*, optional  
The p corresponding to the one of the p-distance (distance metric used during the model computation)

## Methods

The KNeighborsRegressor object has four main methods:

```
1 # Save a table or a view in the DB corresponding to the model predictions for
  all the classes
  def deploy_to_DB(self, name: str, view: bool = True)
3
  # Fit the model with the input columns
5 def fit(self, input_relation: str, X: list, y: str, test_relation: str = "")
7
  # Compute different metrics to evaluate the model
  def regression_report(self)
9
  # Compute the selected metric
11 def score(self, method: str = "r2")
```

## Example

```
1 from vertica_ml_python.learn.neighbors import KNeighborsRegressor
3
  # We can build the model
  model = KNeighborsRegressor(cur)
5 model.fit("iris", ["SepalLengthCm"], "SepalWidthCm")
7
  # We can evaluate the model
  model.regression_report()
9
  # Output
11
  value
explained_variance      0.229656749700724
13 max_error              1.32
  median_absolute_error      0.2
15 mean_absolute_error      0.2749333333333333
  mean_squared_error      0.1458453333333333
```

```
17 r2 0.219037147569338
```

### 10.9.3 NearestCentroid

Create a NearestCentroid object by using the K Nearest Centroid Algorithm. This object is using pure SQL to compute all the distances and final score. As KNeighborsClassifier is using the p-distance, it is highly sensible to un-normalized data.

#### initialization

```
1 class NearestCentroid(
2     name: str,
3     cursor,
4     n_neighbors: int = 20,
5     p: int = 2)
```

#### Parameters

- **name:** <str>  
Name of the relation created after fitting the model.
- **cursor:** <object>  
DB cursor.
- **p:** <int>, optional  
The p corresponding to the one of the p-distance (distance metric used during the model computation).

#### Methods

The NearestCentroid object has many methods:

```
1 # Compute different metrics to evaluate the model
2 def classification_report(self, cutoff: float = 0.5, labels = [])
3
4 # Draw the confusion matrix of the model
5 def confusion_matrix(self, pos_label = None, cutoff: float = 0.5)
6
7 # Save a table or a view in the DB corresponding to the model predictions for
8   all the classes
9 def deploy_to_DB(self, name: str, view: bool = True, cutoff = -1, all_classes:
10    bool = False)
11
12 # Fit the model with the input columns
13 def fit(self, input_relation: str, X: list, y: str, test_relation: str = "")
14
15 # Draw the Lift Chart
16 def lift_chart(self, pos_label = None)
17
18 # Draw the PRC Curve
19 def prc_curve(self, pos_label = None)
```

```

19 # Draw the ROC Curve
def roc_curve(self, pos_label = None)

21 # Compute the selected metric

23 def score(self, pos_label = None, cutoff: float = 0.5, method: str = "accuracy
    ")

```

## Attributes

The NearestCentroid object has two main attributes:

```

1 self.centroids # Information on the different centroids
self.classes # The response column classes

```

## Example

```

from vertica_ml_python.learn.neighbors import NearestCentroid

2 # We can build the model
4 model = NearestCentroid(cur)
model.fit("iris", ["SepalLengthCm", "SepalWidthCm"], "Species")

6 # We can evaluate the model
8 model.classification_report()

10 # Output

```

	Iris-setosa	Iris-versicolor	
auc	0.9646000000000002	0.7232	\\
prc_auc	0.901881291162864	0.5053846970363146	\\
accuracy	0.6666666666666667	0.6666666666666667	\\
log_loss	0.22020528846944	0.265883056465362	\\
precision	0.0	0.0	\\
recall	0	0	\\
f1-score	0.0	0.0	\\
mcc	0	0	\\
informedness	-0.3333333333333337	-0.3333333333333337	\\
markedness	0.0	0.0	\\
csi	0.0	0.0	\\
	Iris-virginica		
auc	0.7887		
prc_auc	0.5563484355454329		
accuracy	0.6666666666666667		
log_loss	0.249463099665484		
precision	0.0		
recall	0		
f1-score	0.0		
mcc	0		
informedness	-0.3333333333333337		
markedness	0.0		



34 csi	0.0
--------	-----

### 10.9.4 LocalOutlierFactor

Create a LocalOutlierFactor object by using the Local Outlier Factor algorithm as defined by Markus M. Breunig, Hans-Peter Kriegel, Raymond T. Ng and Jörg Sander. This object is using pure SQL to compute all the distances and final score. It is using CROSS JOIN and may be really expensive in some cases. It will index all the elements of the table in order to be optimal (the CROSS JOIN will happen only with IDs which are integers). As LocalOutlierFactor is using the p-distance, it is highly sensible to un-normalized data.

#### initialization

```

class LocalOutlierFactor(
2     name: str,
    cursor,
4     n_neighbors: int = 20,
    p: int = 2)

```

#### Parameters

- **name:** <str>  
Name of the relation created after fitting the model.
- **cursor:** <object>  
DB cursor.
- **n\_neighbors:** <int>, optional  
Number of neighbors to consider when computing the score.
- **p:** <int>, optional  
The p corresponding to the one of the p-distance (distance metric used during the model computation).

#### Methods

The LocalOutlierFactor object has five main methods:

```

1 # Fit the model with the input columns
def fit(self, input_relation: str, X: list, key_columns: list = [], index = ""
    )
3
# Print the model information
5 def info(self)
7
# Plot the model (only possible if the number of columns <= 3)
def plot(self)
9
# Create a vDataframe using the final relation
11 def to_vdf(self)

```

The index parameter (name of the primary key column in the relation) of the 'fit' method is very important as without it an indexed copy of the main relation will be created (it could be really expensive). It is highly recommended to have a primary key column in the main table to avoid unnecessary computations.

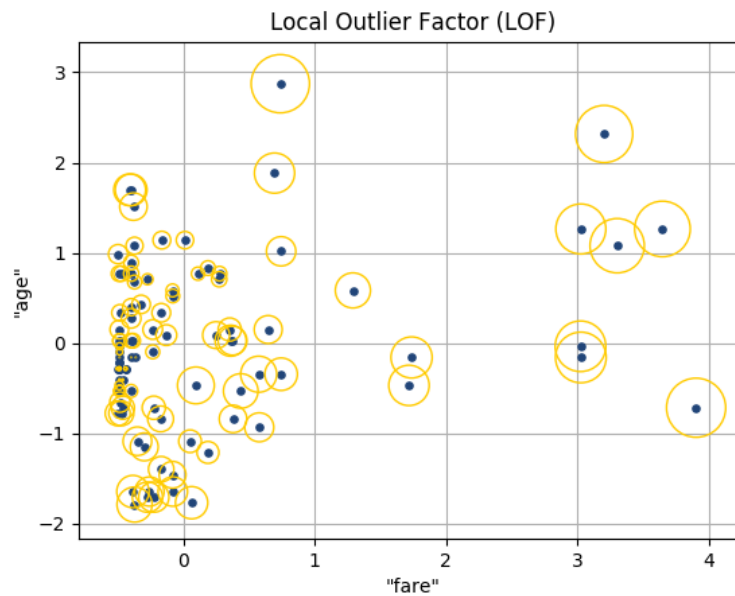
### Attributes

The LocalOutlierFactor object has one main attribute:

```
1 self.n_errors # Number of errors
```

### Example

```
1 from vertica_ml_python import vDataframe
2 from vertica_ml_python.learn.neighbors import LocalOutlierFactor
3
4 # Building a normalized relation of the features, we will use
5 titanic = vDataframe("titanic", cur)
6 # We will use a sample of the data in order to have a beautiful plot
7 titanic.main_relation += " TABLESAMPLE(10) "
8 titanic = titanic.select(["fare", "age"])
9 titanic.normalize()
10 titanic.to_db("titanic_normalize")
11
12 # We can build the model
13 model = LocalOutlierFactor("lof_titanic", cur)
14 model.fit("titanic_normalize", ["fare", "age"])
15
16 # We can see the different information relative to the model
17 model.info()
18
19 # Output
20 All the LOF scores were computed.
21
22 # And Plot the model
23 model.plot()
```



## 10.10 vertica\_ml\_python.learn.plot

### 10.10.1 elbow

```

1 def elbow(
2     X: list,
3     input_relation: str,
4     cursor,
5     n_cluster = (1, 15),
6     init = "kmeanspp",
7     max_iter: int = 50,
8     tol: float = 1e-4)

```

Draw the Elbow Curve. This curve is helpful to find the number of clusters of a KMeans model.

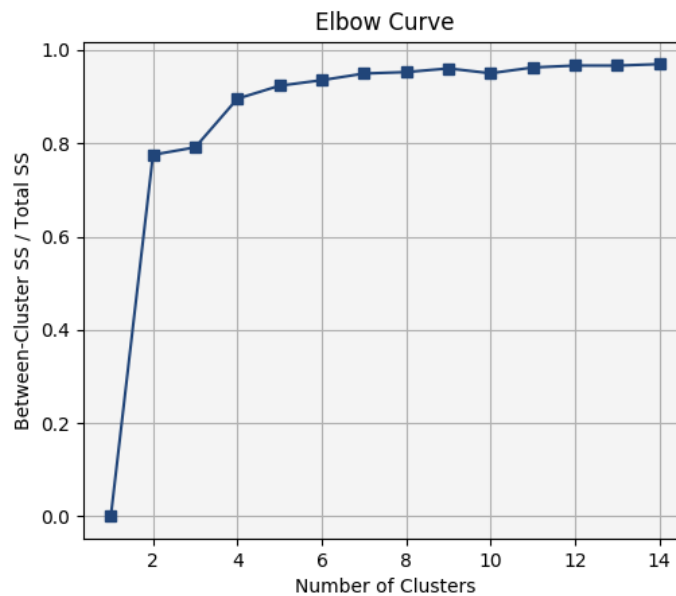
#### Parameters

- **X:** *<list>*  
List of the predictor columns.
- **input\_relation:** *<str>*  
Relation used to train the model.
- **cursor:** *<object>*  
DB cursor.
- **n\_cluster:** *<tuple>*, optional  
Tuple representing the number of cluster to start with and to end with.
- **init:** *<str or list>*, optional  
The method used to find the initial cluster centers. The method can be in {random | kmeanspp}. It can be also a list with the initial cluster centers to use.

- **max\_iter:** *<int>*, optional  
The maximum number of iterations the algorithm performs.
- **tol:** *<float>*, optional  
Determines whether the algorithm has converged. The algorithm is considered converged after no center has moved more than a distance of 'tol' from the previous iteration.

### Example

```
from vertica_ml_python.learn.plot import elbow
# We can build the model
elbow(["PetalLengthCm", "SepalWidthCm", "SepalLengthCm"], "iris", cur)
```



### 10.10.2 lift\_chart

```
def lift_chart(
    y_true: str,
    y_score: str,
    input_relation: str,
    cursor,
    pos_label = 1,
    nbins: int = 1000)
```

Draw the Lift Curve.

#### Parameters

- **y\_true:** *<str>*  
Response Column.

- **y\_score:** *<str>*  
Prediction.
- **input\_relation:** *<str>*  
Input Relation.
- **cursor:** *<object>*  
DB cursor.
- **pos\_label:** *<anytype>*, optional  
Label of the main class.
- **nbins:** *<int>*, optional  
Number of bins used to compute the curve (= number of points).

### 10.10.3 prc\_curve

```
1 def prc_curve(  
3     y_true: str,  
4     y_score: str,  
5     input_relation: str,  
6     cursor,  
7     pos_label = 1,  
8     nbins: int = 1000)
```

Draw the PRC Curve.

#### Parameters

- **y\_true:** *<str>*  
Response Column.
- **y\_score:** *<str>*  
Prediction.
- **input\_relation:** *<str>*  
Input Relation.
- **cursor:** *<object>*  
DB cursor.
- **pos\_label:** *<anytype>*, optional  
Label of the main class.
- **nbins:** *<int>*, optional  
Number of bins used to compute the curve (= number of points).

### 10.10.4 roc\_curve

```
1 def roc_curve(  
3     y_true: str,  
4     y_score: str,  
5     input_relation: str,  
6     cursor,
```

```
pos_label = 1,
nbins: int = 1000)
```

Draw the ROC Curve.

### Parameters

- **y\_true:** *<str>*  
Response Column.
- **y\_score:** *<str>*  
Prediction.
- **input\_relation:** *<str>*  
Input Relation.
- **cursor:** *<object>*  
DB cursor.
- **pos\_label:** *<anytype>*, optional  
Label of the main class.
- **nbins:** *<int>*, optional  
Number of bins used to compute the curve (= number of points).

## 10.11 vertica\_ml\_python.learn.preprocessing

### 10.11.1 Balance

```
def Balance(
    name: str,
    input_relation: str,
    cursor,
    y: str,
    method: str,
    ratio = 0.5)
```

Build a view with an equal distribution of the input data based on the response column.

### Parameters

- **name:** *<str>*  
Output view name.
- **input\_relation:** *<str>*  
Input Relation.
- **cursor:** *<object>*  
DB cursor.
- **y:** *<str>*  
Response column.
- **method:** *<str>*, optional  
Label of the main class.

- **ratio:** *<float>*, optional  
 hybrid\_sampling | over\_sampling | under\_sampling  
 hybrid\_sampling (default): Performs over-sampling and under-sampling on different classes so each class is equally represented.  
 over\_sampling: Over-samples on all classes, with the exception of the most majority class, towards the most majority class's cardinality.  
 under\_sampling: Under-samples on all classes, with the exception of the most minority class, towards the most minority class's cardinality.

### 10.11.2 CountVectorizer

Create a CountVectorizer object which creates the dictionary of the different text columns. During the process, it will create a text index and compute the number of occurrences.

#### Initialization

```

1 class CountVectorizer(
2     name: str,
3     cursor,
4     lowercase: bool = True,
5     max_df: float = 1.0,
6     min_df: float = 0.0,
7     max_features: int = -1,
8     ignore_special: bool = True,
9     max_text_size: int = 2000)

```

#### Parameters

- **name:** *<str>*  
Name of the text index.
- **cursor:** *<object>*  
DB cursor.
- **lowercase:** *<bool>*, optional  
Convert all the elements to lowercase before processing.
- **max\_df:** *<float>*, optional  
Keep the words which represent less than this float in the total dictionary distribution.
- **min\_df:** *<float>*, optional  
Keep the words which represent more than this float in the total dictionary distribution.
- **max\_features:** *<int>*, optional  
Keep only the top words of the dictionary
- **ignore\_special:** *<bool>*, optional  
Ignore all the special characters to build the dictionary.
- **max\_text\_size:** *<int>*, optional  
The maximum size of the column which is the concatenation of all the text columns during the fitting.

#### Methods

The CountVectorizer object has 3 methods:

```

1 # Drop the text index
  def drop(self)
3
  # Fit the model with the input columns
5 def fit(self, input_relation: str, X: list)
7
  # Build a vdf from the output relation
  def to_vdf(self)

```

### Attributes

The CountVectorizer object has two attributes:

```

self.stop_words # The words not added to the vocabulary because of some
                 parameters
2 self.vocabulary # The final vocabulary

```

### Example

```

from vertica_ml_python.learn.preprocessing import CountVectorizer
2
# We can build the model
4 model = CountVectorizer("name_voc", cur)
  model.fit("titanic", ["Name"])
6
# We can export the dictionary
8 model.to_vdf()
10
# Output
12
      token      df  cnt  rnk
12 0      mr  0.148163100524828421  734  1
13 1    miss  0.046023415421881308  228  2
14 2    mrs  0.037343560758982640  185  3
15 3  william  0.016148566814695196   80  4
16 4    john  0.013726281792490916   68  5
17 ...    ...      ...    ...    ...
18 Name: name_voc, Number of rows: 1841, Number of columns: 4

```

### 10.11.3 Normalizer

Create a Normalizer object which can be used to normalize the data.

#### initialization

```

class Normalizer(name: str, cursor, method: str = "zscore")

```

#### Parameters



- **name:** *<str>*  
Name of the model.
- **cursor:** *<object>*  
DB cursor.
- **method:** *<str>*, optional  
The normalization method to use: {minmax | zscore | robust\_zscore}

## Methods

The Normalizer object has 3 methods:

```

1 # Drop the model from the DB
  def drop(self)
3
  # Fit the model with the input columns
5 def fit(self, input_relation: str, X: list)
7
  # Build a vdf from the output relation
  def to_vdf(self, reverse = False)

```

## Attributes

The Normalizer object has only one attribute:

```
self.param # The information about columns used to normalize the data.
```

## Example

```

1 from vertica_ml_python.learn.decomposition import Normalizer
3
  # We can build the model
  model = Normalizer("norm_iris", cur)
5 model.fit("iris", ["SepalLengthCm", "SepalWidthCm"])
7
  # We can look at the model parameters
  model.param
9
  # Output
11      column_name      avg      std_dev
0      sepallengthcm  5.84333333333333  0.828066127977865
13      sepalwidthcm   3.054   0.433594311362172
15
  # We can export the model
  model.to_vdf()
17
  # Output
19      SepalLengthCm      SepalWidthCm
0      -0.897673879196763      1.02861128089724
21      -1.13920048346495      -0.12454037930146

```

```

2      -1.38072708773314      0.33672028477802
23 3      -1.50149038986723      0.10608995273828
25 4      -1.01843718133086      1.25924161293698
...      ...      ...
Name: norm_iris, Number of rows: 150, Number of columns: 2

```

#### 10.11.4 OneHotEncoder

Create a OneHotEncoder object which can be used to encode the data using dummies.

##### initialization

```

class OneHotEncoder(
2     name: str,
     cursor,
4     extra_levels: dict = {},
     drop_first: bool = True,
6     ignore_null: bool = True)

```

##### Parameters

- **name:** *<str>*  
Name of the model.
- **cursor:** *<object>*  
DB cursor.
- **extra\_levels:** *<dict>*, optional  
Additional levels in each category that are not in the input relation.
- **drop\_first:** *<bool>*, optional  
If true, treat the first level of the categorical variable as the reference level.
- **ignore\_null:** *<bool>*, optional  
If false, Null values in input?columns are treated as a categorical level.

##### Methods

The OneHotEncoder object has 3 methods:

```

# Drop the model from the DB
2 def drop(self)

# Fit the model with the input columns
4 def fit(self, input_relation: str, X: list)

# Build a vdf from the output relation
6
8 def to_vdf(self, reverse = False)

```

##### Attributes

The OneHotEncoder object has only one attribute:

```
self.param # The information about columns used to get the data dummies.
```

### Example

```
1 from vertica_ml_python.learn.decomposition import OneHotEncoder
3 # We can build the model
  model = OneHotEncoder("dummies_iris", cur)
5 model.fit("iris", ["Species"])
7 # We can look at the model parameters
  model.param
9
11 # Output
    category_name      category_level      category_level_index
12 0          species      Iris-setosa              0
13 1          species      Iris-versicolor          1
14 2          species      Iris-virginica           2
15
17 # We can export the model
  model.to_vdf()
19
21 # Output
    species      species_iris-versicolor      species_iris-virginica
22 0      Iris-setosa              0              0
23 1      Iris-setosa              0              0
24 2      Iris-setosa              0              0
25 3      Iris-setosa              0              0
26 4      Iris-setosa              0              0
27 ...          ...          ...          ...
28 Name: dummies_iris, Number of rows: 150, Number of columns: 3
```

## 10.12 vertica\_ml\_python.learn.svm

### 10.12.1 LinearSVC

Create a LinearSVC object by using the Vertica Highly Distributed and Scalable SVM on the data.

#### initialization

```
1 class LinearSVC(
    name: str,
3     cursor,
    tol: float = 1e-4,
5     C: float = 1.0,
    fit_intercept: bool = True,
7     intercept_scaling: float = 1.0,
```

```

    intercept_mode: str = "regularized",
    class_weight: list = [1, 1],
    max_iter: int = 100)

```

## Parameters

- **name:** *<str>*  
Name of the relation created after fitting the model.
- **cursor:** *<object>*  
DB cursor.
- **tol:** *<float>*, optional  
Used to control accuracy.
- **C:** *<float>*, optional  
The weight for misclassification cost. The algorithm minimizes the regularization cost and the misclassification cost.
- **fit\_intercept:** *<bool>*, optional  
A bool to fit also the intercept.
- **intercept\_scaling:** *<float>*, optional  
A float value, serves as the value of a dummy feature whose coefficient Vertica uses to calculate the model intercept. Because the dummy feature is not in the training data, its values are set to a constant, by default set to 1.
- **intercept\_mode:** *<str>*, optional  
A string that specifies how to treat the intercept, one of the following: {regularized | unregularized}
- **class\_weight:** *<list>*, optional  
Specifies how to determine weights of the two classes. It can be in {None | auto} or a list of 2 elements.
- **max\_iter:** *<int>*, optional  
The maximum number of iterations that the algorithm performs.

## Methods

The LinearSVC object has many methods:

```

# Add the LinearSVC prediction in a vDataFrame
def add_to_vdf(self, vdf, name: str = "", cutoff: float = 0.5)

# Compute different metrics to evaluate the model
def classification_report(self, cutoff: float = 0.5)

# Draw the confusion matrix of the model
def confusion_matrix(self, cutoff: float = 0.5)

# Save a table or a view in the DB corresponding to the model predictions for
  all the classes
def deploy_to_DB(self, name: str, view: bool = True, cutoff = -1)

# Drop the model from the DB

```

```

14 def drop(self)
16 # Compute the importance of each feature
17 def features_importance(self)
18
19 # Fit the model with the input columns
20 def fit(self, input_relation: str, X: list, y: str, test_relation: str = "")
21
22 # Draw the Lift Chart
23 def lift_chart(self)
24
25 # Plot the SVM if it is possible (The length of X must be lesser of equal to
26   3)
27 def plot(self)
28
29 # Draw the PRC Curve
30 def prc_curve(self)
31
32 # Draw the ROC Curve
33 def roc_curve(self)
34
35 # Compute the selected metric
36 def score(self, cutoff: float = 0.5, method: str = "accuracy")

```

### Attributes

The LinearSVC object has only one attribute:

```

1 self.coef # Informations about the model coefficients

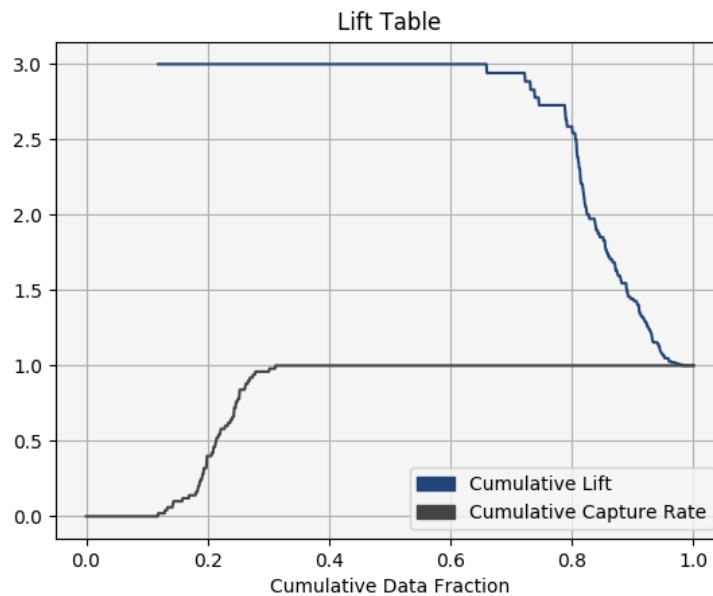
```

### Example

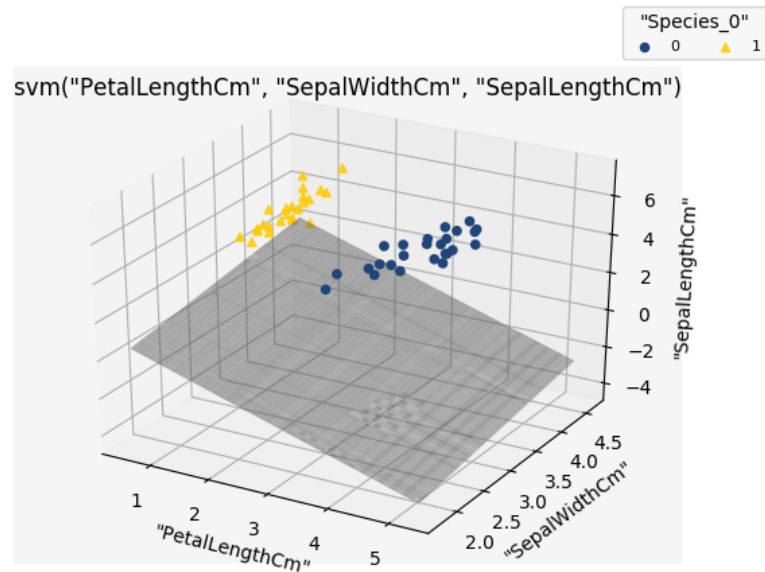
```

1 from vertica_ml_python import vDataframe
2 from vertica_ml_python.learn.svm import LinearSVC
3
4 # We create dummies
5 iris = vDataframe("iris", cur)
6 iris["Species"].get_dummies(use_numbers_as_suffix = True)
7 iris.to_db("iris_dummy")
8
9 # We can build the model
10 model = LinearSVC("svc_iris", cur)
11 model.fit("iris_dummy", ["PetalLengthCm", "SepalWidthCm", "SepalLengthCm"], "
    Species_0")
12
13 # We can draw the lift chart of the model
14 model.lift_chart()

```



```
# We can also draw the model
model.plot()
```



### 10.12.2 LinearSVR

Create a LinearSVR object by using the Highly Distributed and Scalable SVM on the data.

#### initialization

```
class LinearSVR(
```

```

2     name: str,
        cursor,
4     tol: float = 1e-4,
        C: float = 1.0,
6     fit_intercept: bool = True,
        intercept_scaling: float = 1.0,
8     intercept_mode: str = "regularized",
        acceptable_error_margin: float = 0.1,
10    max_iter: int = 100)

```

## Parameters

- **name:** <str>  
Name of the model.
- **cursor:** <object>  
DB cursor.
- **tol:** <float>, optional  
Used to control accuracy.
- **C:** <float>, optional  
The weight for misclassification cost. The algorithm minimizes the regularization cost and the misclassification cost.
- **fit\_intercept:** <bool>, optional  
A bool to fit also the intercept.
- **intercept\_scaling:** <float>, optional  
A float value, serves as the value of a dummy feature whose coefficient Vertica uses to calculate the model intercept. Because the dummy feature is not in the training data, its values are set to a constant, by default set to 1.
- **intercept\_mode:** <str>, optional  
A string that specifies how to treat the intercept, one of the following: {regularized | unregularized}
- **acceptable\_error\_margin:** <float>, optional  
Defines the acceptable error margin. Any data points outside this region add a penalty to the cost function.
- **max\_iter:** <int>, optional  
The maximum number of iterations that the algorithm performs.

## Methods

The LinearSVR object has many methods:

```

# Add the LinearSVR prediction in a vDataFrame
2 def add_to_vdf(self, vdf, name: str = "")

4 # Save a table or a view in the DB corresponding to the model predictions for
  all the classes
  def deploy_to_DB(self, name: str, view: bool = True, cutoff = -1)

6 # Drop the model from the DB

```

```

8 def drop(self)
10 # Compute the importance of each feature
11 def features_importance(self)
12 # Fit the model with the input columns
14 def fit(self, input_relation: str, X: list, y: str, test_relation: str = "")
16 # Plot the SVM if it is possible (The length of X must be lesser or equal to
17     3)
18 def plot(self)
19 # Compute different metrics to evaluate the model
20 def regression_report(self)
22 # Compute the selected metric
23 def score(self, method: str = "r2")

```

### Attributes

The LinearSVR object has only one attribute:

```

1 self.coef # Informations about the model coefficients

```

### Example

```

1 from vertica_ml_python.learn.svm import LinearSVR
3 # We can build the model
4 model = LinearSVR("svc_iris", cur)
5 model.fit("iris", ["SepalLengthCm"], "SepalWidthCm")
7 # We can evaluate the model
8 model.regression_report()
9
10 # Output
11
12                                     value
13 explained_variance                -0.0357335274222341
14 max_error                        1.3548634384927
15 median_absolute_error            0.287106492764341
16 mean_absolute_error              0.342827242830171
17 mean_squared_error              0.193424390470397
18 r2                              -0.035736010600985
19
20 # We can also get the model coefficients
21 model.coef()
22
23 # Output
24
25      predictor      coefficient

```



0	Intercept	2.71974116342001
1	sepalengthcm	0.0570869119451395

### 10.13 vertica\_ml\_python.learn.tree

The four following algorithm have the same methods and attributes than the Random Forest models. Decision trees can be seen as Random Forest with one tree and using the entire dataset. Dummy Trees are infinite depth Decision Trees.

#### 10.13.1 DecisionTreeClassifier

```

1 def DecisionTreeClassifier(
    name: str,
    cursor,
    max_features = "auto",
    max_leaf_nodes: int = 1e9,
    max_depth: int = 100,
    min_samples_leaf: int = 1,
    min_info_gain: float = 0.0,
    nbins: int = 32)

```

Single Decision Tree Classifier.

#### 10.13.2 DecisionTreeRegressor

```

1 def DecisionTreeRegressor(
    name: str,
    cursor,
    max_features = "auto",
    max_leaf_nodes: int = 1e9,
    max_depth: int = 100,
    min_samples_leaf: int = 1,
    min_info_gain: float = 0.0,
    nbins: int = 32)

```

Single Decision Tree Regressor.

#### 10.13.3 DummyTreeClassifier

```

1 def DummyTreeClassifier(name: str, cursor)

```

Dummy Tree Classifier. This classifier learns by heart the training data.

#### 10.13.4 DummyTreeRegressor

```
def DummyTreeRegressor(name: str, cursor)
```

Dummy Tree Regressor. This regressor learns by heart the training data.

## 11 Contact

If you have any question or issue, feel free to write it at <https://github.com/vertica/Vertica-ML-Python/issues>. If you really need a specific function or algorithm and it is feasible using Vertica SQL, I can make your wish come true. Write me at [badr.ouali@microfocus.com](mailto:badr.ouali@microfocus.com) and I will try to find a solution to your problem.

