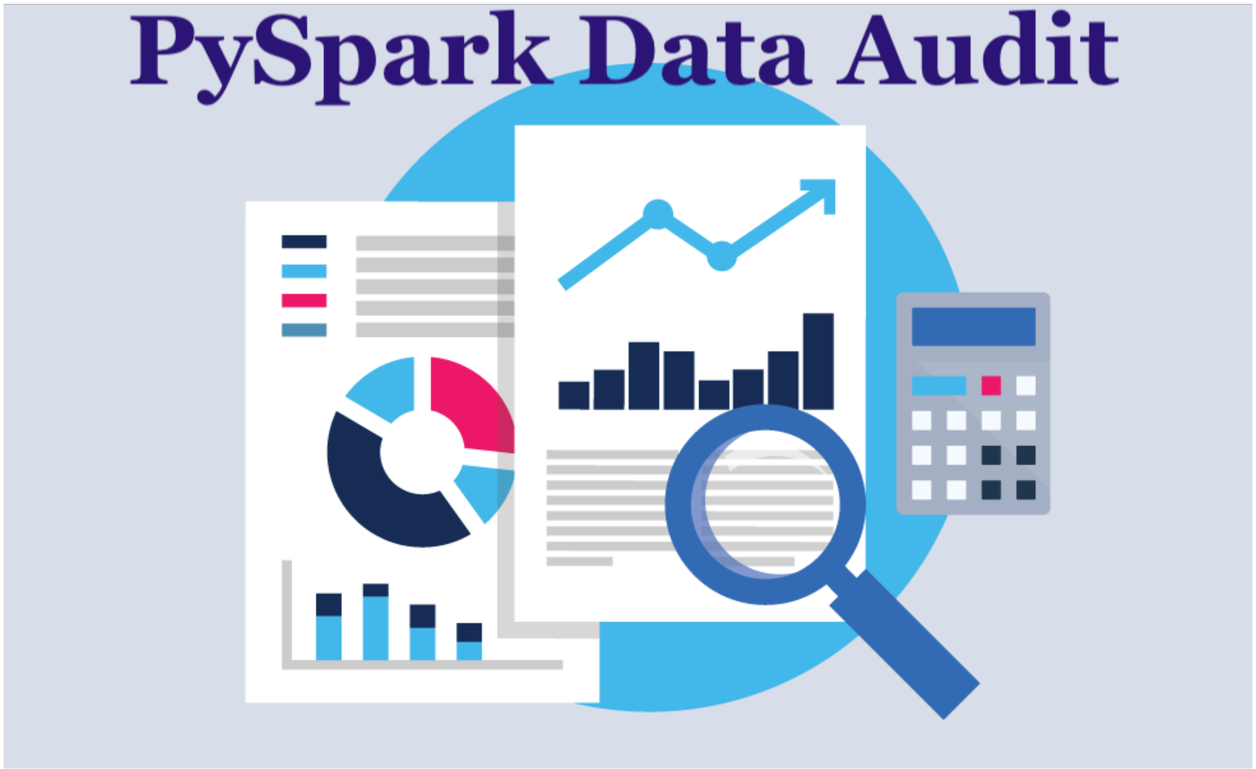
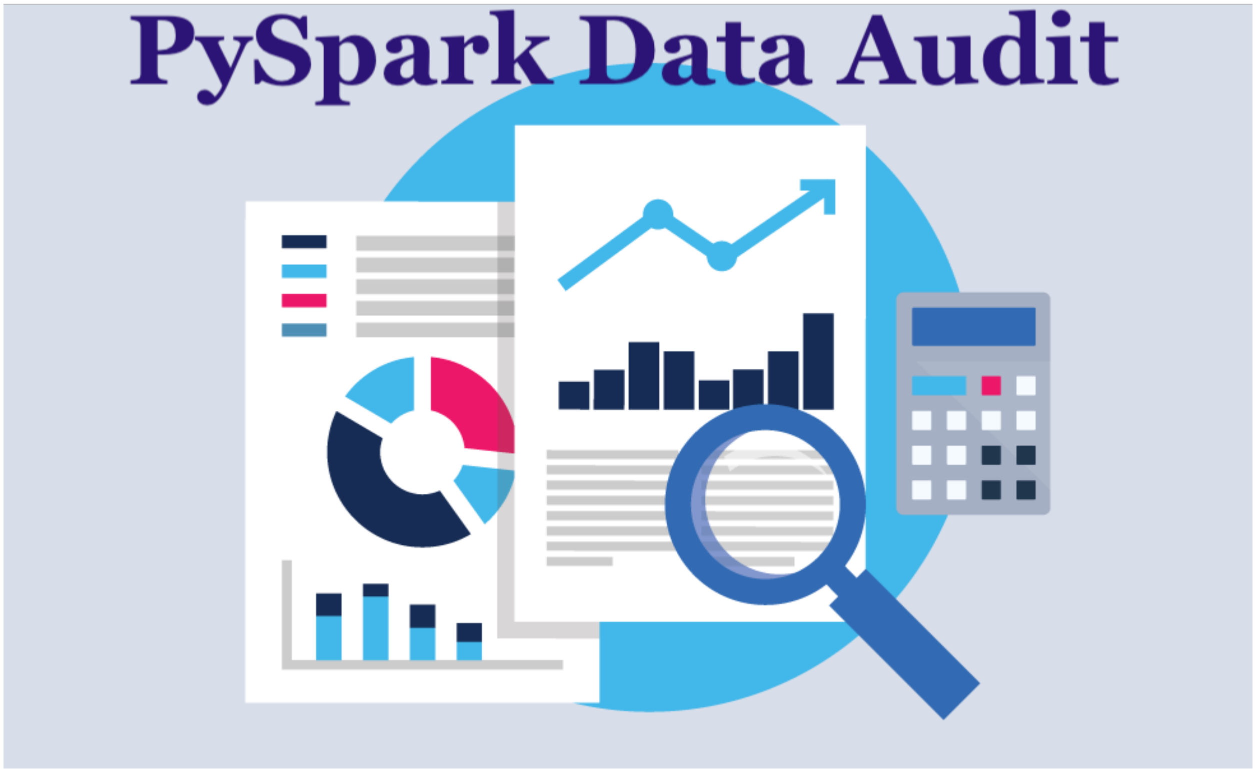


PySparkAudit: PySpark Data Audit

Wenqiang Feng and Yiming Xu

July 02, 2019

CONTENTS



Welcome to our **PySparkAudit: PySpark Data Audit Library API**! The PDF version can be downloaded from HERE.

You can install the `PySparkAudit` from [PyPI](https://pypi.org/project/PySparkAudit):

```
pip install PySparkAudit
```

CHAPTER ONE

PREFACE

Chinese proverb

Good tools are prerequisite to the successful execution of a job. – old Chinese proverb

1.1 About

1.1.1 About this API

This document is the `API` book for our **PySparkAudit**: PySpark Data Audit Library [PySparkAudit] API. The PDF version can be downloaded from HERE. **You may download and distribute it. Please be aware, however, that the note contains typos as well as inaccurate or incorrect description.**

The `API` assumes that the reader has a preliminary knowledge of `python` programing and `Linux`. And this document is generated automatically by using sphinx.

The python version **PyAudit**: Python Data Audit Library API can be found at [PyAudit].

1.1.2 About the author

- **Wenqiang Feng**
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  - Harvard University
  - Email: yimingxu@g.harvard.edu

- **Biography**

  Wenqiang Feng is Data Scientist within DST's Applied Analytics Group. Dr. Feng's responsibilities include providing DST clients with access to cutting-edge skills and technologies, including Big Data analytic solutions, advanced analytic and data enhancement techniques and modeling.

  Dr. Feng has deep analytic expertise in data mining, analytic systems, machine learning algorithms, business intelligence, and applying Big Data tools to strategically solve industry problems in a cross-functional business. Before joining DST, Dr. Feng was an IMA Data Science Fellow at The Institute for Mathematics and its Applications (IMA) at the University of Minnesota. While there, he helped startup companies make marketing decisions based on deep predictive analytics.

  Dr. Feng graduated from University of Tennessee, Knoxville, with Ph.D. in Computational Mathematics and Master's degree in Statistics. He also holds Master's degree in Computational Mathematics from Missouri University of Science and Technology (MST) and Master's degree in Applied Mathematics from the University of Science and Technology of China (USTC).

- **Declaration**

  The work of Wenqiang Feng was supported by the IMA, while working at IMA. However, any opinion, finding, and conclusions or recommendations expressed in this material are those of the author and do not necessarily reflect the views of the IMA, UTK, DST and Harvard University.

1.2 Acknowledgement

At here, Wenqiang Feng would like to thank **Weiyu Wang** at Missouri University of Science and Technology and **Jiangtao (Lotto) Xie** at Purdue University for the unit testing and valuable disscussion.

1.3 Feedback and suggestions

Your comments and suggestions are highly appreciated. I am more than happy to receive corrections, suggestions or feedbacks through email (Wenqiang Feng: von198@gmail.com and Yiming Xu: yimingxu@g.harvard.edu) for improvements.

CHAPTER

TWO

HOW TO INSTALL

2.1 Install with `pip`

You can install the `PySparkAudit` from [PyPI](https://pypi.org/project/PySparkAudit):

```
pip install PySparkAudit
```

2.2 Install from Repo

2.2.1 Clone the Repository

```
git clone https://github.com/runawayhorse001/PySparkAudit.git
```

2.2.2 Install

```
cd PySparkAudit
pip install -r requirements.txt
python setup.py install
```

2.3 Uninstall

```
pip uninstall statspy
```

2.4 Test

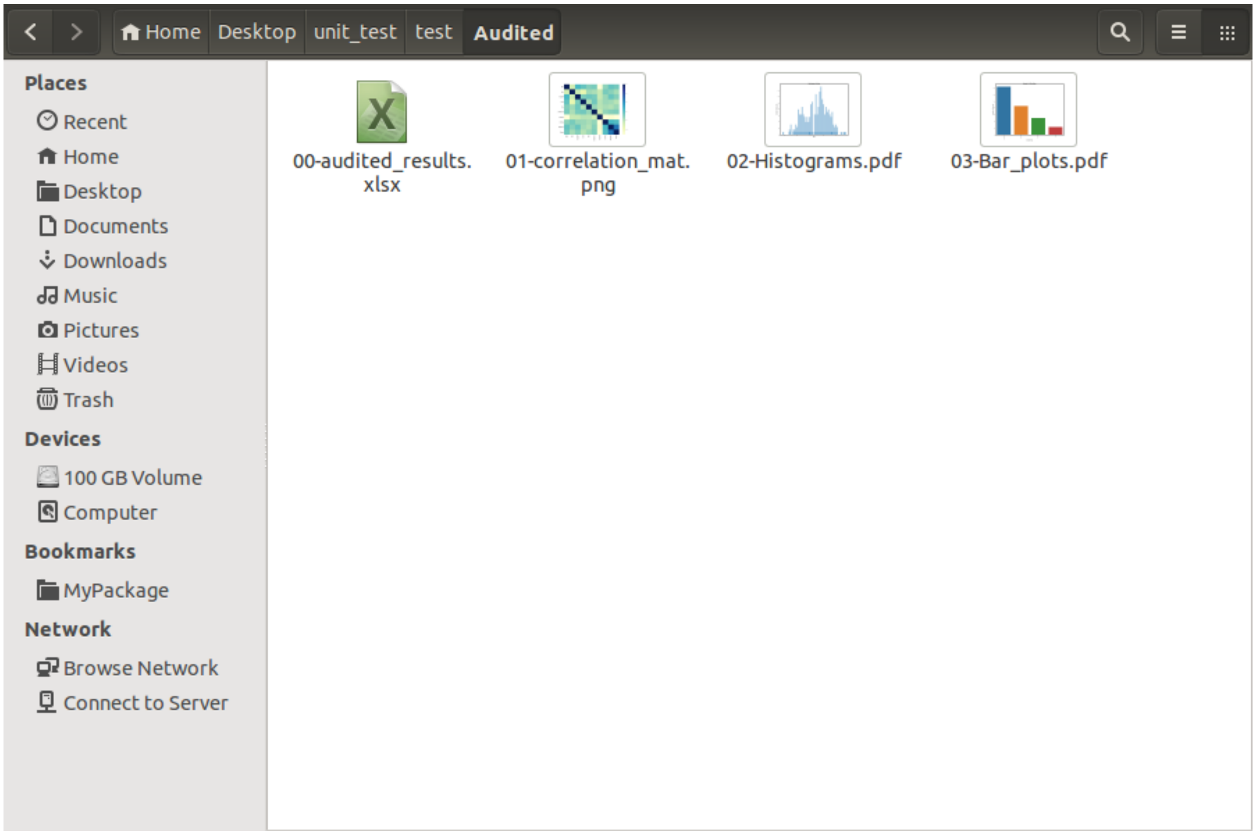
2.4.1 Run test code

```
cd PySparkAudit/test
python test.py
```

test.py

```
from pyspark.sql import SparkSession

spark = SparkSession \
    .builder \
    .appName("Python Spark regression example") \
    .config("spark.some.config.option", "some-value") \
    .getOrCreate()


# from PySparkAudit import dtypes_class, hist_plot, bar_plot, freq_
↪items,feature_len
# from PySparkAudit import dataset_summary, rates, trend_plot

# path = '/home/feng/Desktop'

# import PySpark Audit function
from PySparkAudit import auditing

# load dataset
data = spark.read.csv(path='Heart.csv',
                      sep=',', encoding='UTF-8', comment=None,␣
↪header=True, inferSchema=True)

# auditing in one function
print(auditing(data, display=True))
```

2.4.2 Audited Results


Home
Desktop
unit_test
test
Audited
Places
Recent
Home
Desktop
Documents
Downloads
Music
Pictures
Videos
Trash
Devices
100 GB Volume
Computer
Bookmarks
MyPackage
Network
Browse Network
Connect to Server
00-audited_results.xlsx
01-correlation_mat.png
02-Histograms.pdf
03-Bar_plots.pdf

CHAPTER

THREE

PYSPARK DATA AUDIT FUNCTIONS

3.1 Basic Functions

3.1.1 mkdir

`PySparkAudit.PySparkAudit.`**`mkdir`**`(`*path*`)`

Make a new directory. if it's exist, keep the old files.

Parameters **`path`** – the directory path

3.1.2 mkdir_clean

`PySparkAudit.PySparkAudit.`**`mkdir_clean`**`(`*path*`)`

Make a new directory. if it's exist, remove the old files.

Parameters **`path`** – the directory path

3.1.3 df_merge

`PySparkAudit.PySparkAudit.`**`df_merge`**`(`*dfs*, *key*, *how='left'*`)`

Merge multiple pandas data frames with same key.

Parameters

- **`dfs`** – name list of the data frames
- **`key`** – key for join
- **`how`** – method for join, the default value is left

Returns merged data frame

3.1.4 data_types

PySparkAudit.PySparkAudit.**data_types**(*df_in*, *tracking=False*)

Generate the data types of the rdd data frame.

Parameters

- **df_in** – the input rdd data frame
- **tracking** – the flag for displaying CPU time, the default value is False

Returns data types pandas data frame

3.1.5 dtypes_class

PySparkAudit.PySparkAudit.**dtypes_class**(*df_in*)

Generate the data type categories: numerical, categorical, date and unsupported category.

Parameters **df_in** – the input rdd data frame

Returns data type categories

3.1.6 counts

PySparkAudit.PySparkAudit.**counts**(*df_in*, *tracking=False*)

Generate the row counts and not null rows and distinct counts for each feature.

Parameters

- **df_in** – the input rdd data frame
- **tracking** – the flag for displaying CPU time, the default value is False

Returns the counts in pandas data frame

3.1.7 describe

PySparkAudit.PySparkAudit.**describe**(*df_in*, *columns=None*, *tracking=False*)

Generate the simple data frame description using $.describe()$ function in pyspark.

Parameters

- **df_in** – the input rdd data frame
- **columns** – the specific feature columns, the default value is None
- **tracking** – the flag for displaying CPU time, the default value is False

Returns the description in pandas data frame

3.1.8 percentiles

`PySparkAudit.PySparkAudit.`**`percentiles`**(*df_in*, *deciles=False*, *tracking=False*)

Generate the percentiles for rdd data frame.

Parameters

- **`df_in`** – the input rdd data frame
- **`deciles`** – the flag for generate the deciles
- **`tracking`** – the flag for displaying CPU time, the default value is False

Returns percentiles in pandas data frame

3.1.9 feature_len

`PySparkAudit.PySparkAudit.`**`feature_len`**(*df_in*, *tracking=False*)

Generate feature length statistical results for each feature in the rdd data frame.

Parameters

- **`df_in`** – the input rdd data frame
- **`tracking`** – the flag for displaying CPU time, the default value is False

Returns the feature length statistical results in pandas data frame

3.1.10 freq_items

`PySparkAudit.PySparkAudit.`**`freq_items`**(*df_in*, *top_n=5*, *tracking=False*)

Generate the top_n frequent items in for each feature in the rdd data frame.

Parameters

- **`df_in`** – the input rdd data frame
- **`top_n`** – the number of the most frequent item
- **`tracking`** – the flag for displaying CPU time, the default value is False

Returns

3.1.11 rates

`PySparkAudit.PySparkAudit.`**`rates`**(*df_in*, *columns=None*, *numeric=True*, *tracking=False*)

Generate the null, empty, negative, zero and positive value rates and feature variance for each feature in the rdd data frame.

Parameters

- **`df_in`** – the input rdd data frame
- **`columns`** – the specific feature columns, the default value is None
- **`numeric`** – the flag for numerical rdd data frame, the default value is True
- **`tracking`** – the flag for displaying CPU time, the default value is False

Returns the null, empty, negative, zero and positive value rates and feature variance in pandas data frame

3.1.12 corr_matrix

`PySparkAudit.PySparkAudit.`**`corr_matrix`**(*df_in*, *method='pearson'*, *output_dir=None*, *rotation=True*, *display=False*, *tracking=False*)

Generate the correlation matrix and heat map plot for rdd data frame.

Parameters

- **`df_in`** – the input rdd data frame
- **`method`** – the method which applied to calculate the correlation matrix: pearson or spearman. the default value is pearson
- **`output_dir`** – the out put directory, the default value is the current working directory
- **`rotation`** – the flag for rotating the xticks in the plot, the default value is True
- **`display`** – the flag for displaying the figures, the default value is False
- **`tracking`** – the flag for displaying CPU time, the default value is False

Returns the correlation matrix in pandas data frame

3.2 Plot Functions

3.2.1 hist_plot

`PySparkAudit.PySparkAudit.`**`hist_plot`**(*df_in*, *bins=50*, *output_dir=None*, *sample_size=None*, *display=False*, *tracking=False*)

Histogram plot for the numerical features in the rdd data frame. **This part is super time and memory consuming.** If the data size is larger than 10,000, the histograms will be saved in .pdf format. Otherwise, the histograms will be saved in .png format in hist folder.

If your time and memory are limited, you can use sample_size to generate the subset of the data frame to generate the histograms.

Parameters

- **`df_in`** – the input rdd data frame
- **`bins`** – the number of bins for generate the bar plots
- **`output_dir`** – the out put directory, the default value is the current working directory
- **`sample_size`** – the size for generate the subset from the rdd data frame, the default value none
- **`display`** – the flag for displaying the figures, the default value is False
- **`tracking`** – the flag for displaying CPU time, the default value is False

3.2.2 bar_plot

`PySparkAudit.PySparkAudit.`**`bar_plot`**(*df_in*, *top_n=20*, *rotation=True*, *output_dir=None*, *display=False*, *tracking=False*)

Bar plot for the categorical features in the rdd data frame.

Parameters

- **`df_in`** – the input rdd data frame
- **`top_n`** – the number of the most frequent feature to show in the bar plot
- **`rotation`** – the flag for rotating the xticks in the plot, the default value is True
- **`output_dir`** – the out put directory, the default value is the current working directory
- **`display`** – the flag for displaying the figures, the default value is False

- **tracking** – the flag for displaying CPU time, the default value is False

3.2.3 trend_plot

PySparkAudit.PySparkAudit.**trend_plot**(*df_in*, *types='day'*, *d_time=None*, *rotation=True*, *output_dir=None*, *display=False*, *tracking=False*)

Trend plot for the aggregated time series data if the rdd data frame has date features and numerical features.

Parameters

- **df_in** – the input rdd data frame
- **types** – the types for time feature aggregation: day, month, year, the default value is day
- **d_time** – the specific feature name of the date feature, the default value is the first date feature in the rdd data frame
- **rotation** – the flag for rotating the xticks in the plot, the default value is True
- **output_dir** – the out put directory, the default value is the current working directory
- **display** – the flag for displaying the figures, the default value is False
- **tracking** – the flag for displaying CPU time, the default value is False

3.3 Summary Functions

3.3.1 dataset_summary

PySparkAudit.PySparkAudit.**dataset_summary**(*df_in*, *tracking=False*)

The data set basics summary.

Parameters

- **df_in** – the input rdd data frame
- **tracking** – the flag for displaying CPU time, the default value is False

Returns data set summary in pandas data frame

3.3.2 numeric_summary

`PySparkAudit.PySparkAudit.`**`numeric_summary`**`(`*df_in*, *columns=None*, *deciles=False*, *top_n=5*, *tracking=False*`)`

The auditing function for numerical rdd data frame.

Parameters

- **`df_in`** – the input rdd data frame
- **`columns`** – the specific feature columns, the default value is None
- **`deciles`** – the flag for generate the deciles
- **`top_n`** – the number of the most frequent item
- **`tracking`** – the flag for displaying CPU time, the default value is False

Returns the audited results for the numerical features in pandas data frame

3.3.3 category_summary

`PySparkAudit.PySparkAudit.`**`category_summary`**`(`*df_in*, *columns=None*, *top_n=5*, *tracking=False*`)`

The auditing function for categorical rdd data frame.

Parameters

- **`df_in`** – the input rdd data frame
- **`columns`** – the specific feature columns, the default value is None
- **`top_n`** – the number of the most frequent item
- **`tracking`** – the flag for displaying CPU time, the default value is False

Returns the audited results for the categorical features in pandas data frame

3.4 Auditing Function

3.4.1 auditing

PySparkAudit.PySparkAudit.**auditing**(*df_in*, *writer=None*, *columns=None*, *deciles=False*, *top_freq_item=5*, *bins=50*, *top_cat_item=20*, *method='pearson'*, *output_dir=None*, *types='day'*, *d_time=None*, *rotation=True*, *sample_size=None*, *display=False*, *tracking=False*)

The wrapper of auditing functions.

Parameters

- **df_in** – the input rdd data frame
- **writer** – the writer for excel output
- **columns** – the specific feature columns, the default value is None
- **deciles** – the flag for generate the deciles
- **top_freq_item** – the number of the most frequent item
- **bins** – the number of bins for generate the bar plots
- **top_cat_item** – the number of the most frequent feature to show in the bar plot
- **method** – the method which applied to calculate the correlation matrix: pearson or spearman. the default value is pearson
- **output_dir** – the out put directory, the default value is the current working directory
- **types** – the types for time feature aggregation: day, month, year, the default value is day
- **d_time** – the specific feature name of the date feature, the default value is the first date feature in the rdd data frame
- **rotation** – the flag for rotating the xticks in the plot, the default value is True
- **sample_size** – the size for generate the subset from the rdd data frame, the default value none
- **display** – the flag for displaying the figures, the default value is False
- **tracking** – the flag for displaying CPU time, the default value is False

Returns the all audited results in pandas data frame

3.5 Plotting Function

3.5.1 fig_plots

`PySparkAudit.PySparkAudit.`**`fig_plots`**(*df_in*, *output_dir=None*, *bins=50*, *top_n=20*, *types='day'*, *d_time=None*, *rotation=True*, *sample_size=None*, *display=False*, *tracking=False*)

The wrapper for the plot functions.

Parameters

- **`df_in`** – the input rdd data frame
- **`output_dir`** – the out put directory, the default value is the current working directory
- **`bins`** – the number of bins for generate the bar plots
- **`top_n`** – the number of the most frequent feature to show in the bar plot
- **`types`** – the types for time feature aggregation: day, month, year, the default value is day
- **`d_time`** – the specific feature name of the date feature, the default value is the first date feature in the rdd data frame
- **`rotation`** – the flag for rotating the xticks in the plot, the default value is True
- **`sample_size`** – the size for generate the subset from the rdd data frame, the default value none
- **`display`** – the flag for displaying the figures, the default value is False
- **`tracking`** – the flag for displaying CPU time, the default value is False

CHAPTER

FOUR

AUDITING DEMOS

The following demos are designed to show how to use `PySparkAudit` to aduit rdd `DataFrame`.

4.1 Auditing function by function

For example:

```
from pyspark.sql import SparkSession

spark = SparkSession \
    .builder \
    .appName("Python Spark regression example") \
    .config("spark.some.config.option", "some-value") \
    .getOrCreate()


# import PySpark Audit functions
from PySparkAudit import data_types, hist_plot, bar_plot, freq_items,
↪feature_len
from PySparkAudit import dataset_summary, rates
from PySparkAudit import trend_plot, auditing

# load dataset
data = spark.read.csv(path='Heart.csv',
                      sep=',', encoding='UTF-8', comment=None,␣
↪header=True, inferSchema=True)

# audit function by function

# data types
print(data_types(data))

# check frequent items
```

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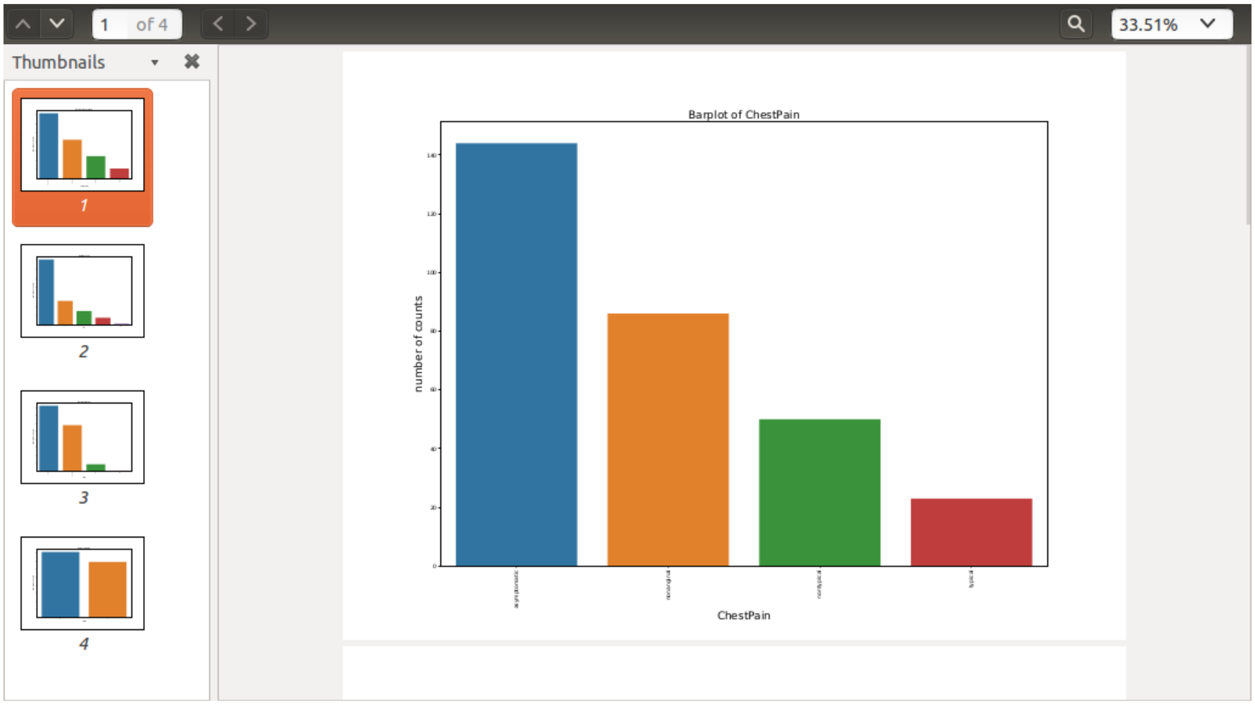
```
print(freq_items(data))

# bar plot for categorical features
bar_plot(data,  display=True)
```

Result:

```
      feature  dtypes
0          Age     int
1          Sex     int
2    ChestPain  string
3       RestBP     int
4         Chol     int
5          Fbs     int
6      RestECG     int
7        MaxHR     int
8        ExAng     int
9      Oldpeak  double
10       Slope     int
11          Ca  string
12        Thal  string
13         AHD  string
      feature                            freq_items[value, freq]
0          Age  [[58, 19], [57, 17], [54, 16], [59, 14], [52, ...
1          Sex                                [[1, 206], [0, 97]]
2    ChestPain  [[asymptomatic, 144], [nonanginal, 86], [nonty...
3       RestBP  [[120, 37], [130, 36], [140, 32], [110, 19], [...
4         Chol  [[197, 6], [234, 6], [204, 6], [254, 5], [212,...
5          Fbs                                [[0, 258], [1, 45]]
6      RestECG                       [[0, 151], [2, 148], [1, 4]]
7        MaxHR  [[162, 11], [163, 9], [160, 9], [152, 8], [132...
8        ExAng                                [[0, 204], [1, 99]]
9      Oldpeak  [[0.0, 99], [1.2, 17], [0.6, 14], [1.0, 14], [...
10       Slope                      [[1, 142], [2, 140], [3, 21]]
11          Ca     [[0, 176], [1, 65], [2, 38], [3, 20], [NA, 4]]
12        Thal  [[normal, 166], [reversable, 117], [fixed, 18]...
13         AHD                            [[No, 164], [Yes, 139]]
================================================================
The Bar plot Bar_plots.pdf was located at:
/home/feng/Dropbox/MyTutorial/PySparkAudit/test/Audited

Process finished with exit code 0
```

and



4.2 Auditing in one function

For example:

```
from pyspark.sql import SparkSession

spark = SparkSession \
    .builder \
    .appName("Python Spark regression example") \
    .config("spark.some.config.option", "some-value") \
    .getOrCreate()


# from PySparkAudit import dtypes_class, hist_plot, bar_plot, freq_
↪items,feature_len
# from PySparkAudit import dataset_summary, rates, trend_plot

# path = '/home/feng/Desktop'

# import PySpark Audit function
from PySparkAudit import auditing

# load dataset
data = spark.read.csv(path='Heart.csv',
                      sep=',', encoding='UTF-8', comment=None,␣
↪header=True, inferSchema=True)
```

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```
# auditing in one function
print(auditing(data, display=True))
```

Result:

4.2.1 print in bash

```
================================================================
The audited results summary audited_results.xlsx was located at:
/home/feng/Dropbox/MyTutorial/PySparkAudit/test/Audited
================================================================
The correlation matrix plot Corr.png was located at:
/home/feng/Dropbox/MyTutorial/PySparkAudit/test/Audited
================================================================
The Histograms plot Histograms.pdf was located at:
/home/feng/Dropbox/MyTutorial/PySparkAudit/test/Audited
Histograms plots are done!
================================================================
The Bar plot Bar_plots.pdf was located at:
/home/feng/Dropbox/MyTutorial/PySparkAudit/test/Audited
Caution: no date features in the dataset!!!
Generate all audited results took = 29.093122243881226 s
================================================================
The auditing processes are DONE!!!
(   feature  dtypes  row_count    ...     rate_neg  rate_zero  rate_pos
0       Age     int        303    ...          0.0   0.000000  1.000000
1       Sex     int        303    ...          0.0   0.320132  0.679868
2    RestBP     int        303    ...          0.0   0.000000  1.000000
3      Chol     int        303    ...          0.0   0.000000  1.000000
4       Fbs     int        303    ...          0.0   0.851485  0.148515
5   RestECG     int        303    ...          0.0   0.498350  0.501650
6     MaxHR     int        303    ...          0.0   0.000000  1.000000
7     ExAng     int        303    ...          0.0   0.673267  0.326733
8   Oldpeak  double        303    ...          0.0   0.326733  0.673267
9     Slope     int        303    ...          0.0   0.000000  1.000000

[10 rows x 22 columns],      feature  dtypes     ...      rate_null ␣
↪rate_empty
0  ChestPain  string     ...            0.0         0.0
1         Ca  string     ...            0.0         0.0
2       Thal  string     ...            0.0         0.0
3        AHD  string     ...            0.0         0.0
```

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```
[4 rows x 12 columns],                       Age        Sex     RestBP     ...    ␣
↪    ExAng    Oldpeak      Slope
Age       1.000000 -0.097542  0.284946    ...     0.091661  0.203805  0.
↪161770
Sex      -0.097542  1.000000 -0.064456    ...     0.146201  0.102173  0.
↪037533
RestBP    0.284946 -0.064456  1.000000    ...     0.064762  0.189171  0.
↪117382
Chol      0.208950 -0.199915  0.130120    ...     0.061310  0.046564 -0.
↪004062
Fbs       0.118530  0.047862  0.175340    ...     0.025665  0.005747  0.
↪059894
RestECG   0.148868  0.021647  0.146560    ...     0.084867  0.114133  0.
↪133946
MaxHR    -0.393806 -0.048663 -0.045351    ...    -0.378103 -0.343085 -0.
↪385601
ExAng     0.091661  0.146201  0.064762    ...     1.000000  0.288223  0.
↪257748
Oldpeak   0.203805  0.102173  0.189171    ...     0.288223  1.000000  0.
↪577537
Slope     0.161770  0.037533  0.117382    ...     0.257748  0.577537  1.
↪000000

[10 rows x 10 columns])

Process finished with exit code 0
```

4.2.2 Audited results folder

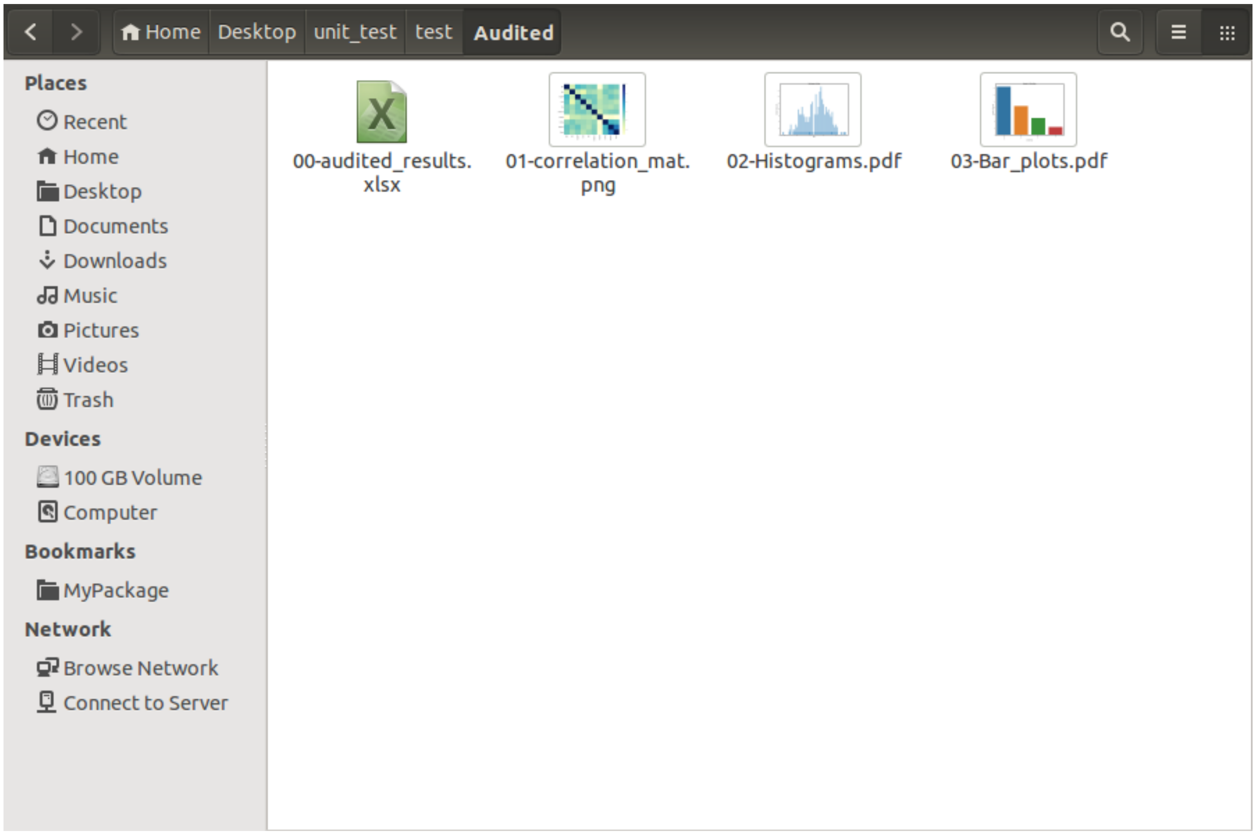
The files in `00-audited_results.xlsx`:

1. Dataset_summary

2. Numeric_summary

3. Category_summary

4. Correlation_matrix



5. Histograms in `Histograms.pdf`

6. Barplots in `Bar_plots.pdf`

```
       .,,.
     ,;;*;;;;,
    .-'``;-');;.
   /'  .-.  /*;;
 .'    \d    \;;               .;;;,
/ o      `    \;    ,__.     ,;*;;;*;,
\__, _.__,'   \_.-') __)--.;;;;;*;;;;,
 `""`;;;\       /-')_) __)  `\' ';;;;;;
    ;*;;;        -')  `)_)  |\ |  ;;;;*;
    ;;;;|        `---`    O | | ;;*;;;
    *;*;\|                 O  / ;;;;;*
   ;;;;;/|    .-------\      / ;*;;;;;
  ;;;*;/ \    |        '.   (`. ;;;*;;;
  ;;;;;'. ;   |          )   \ | ;;;;;;
  ,;*;;;;\/   |.        /   /` | ';;;*;
   ;;;;;;/    |/       /   /__/   ';;;
```

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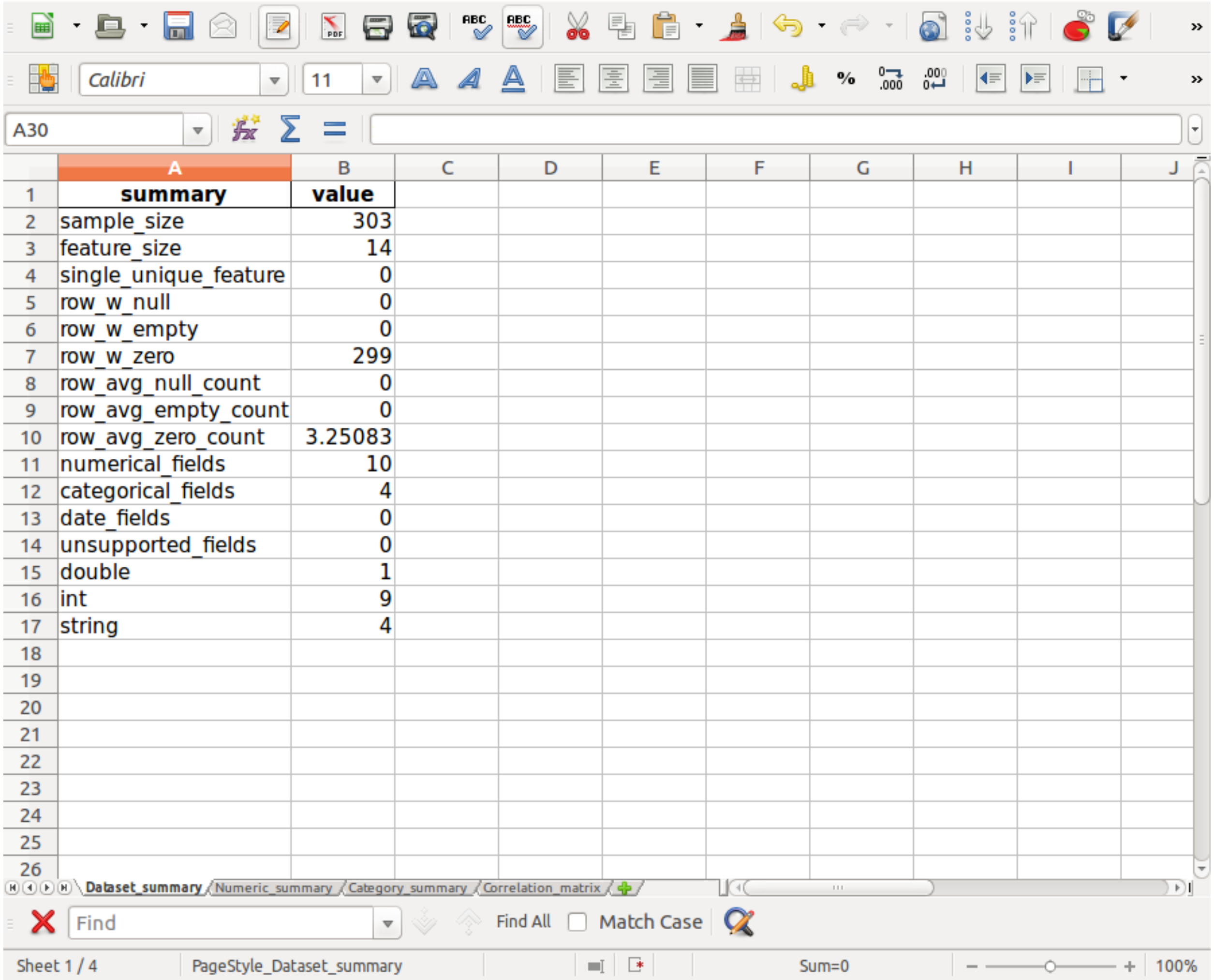
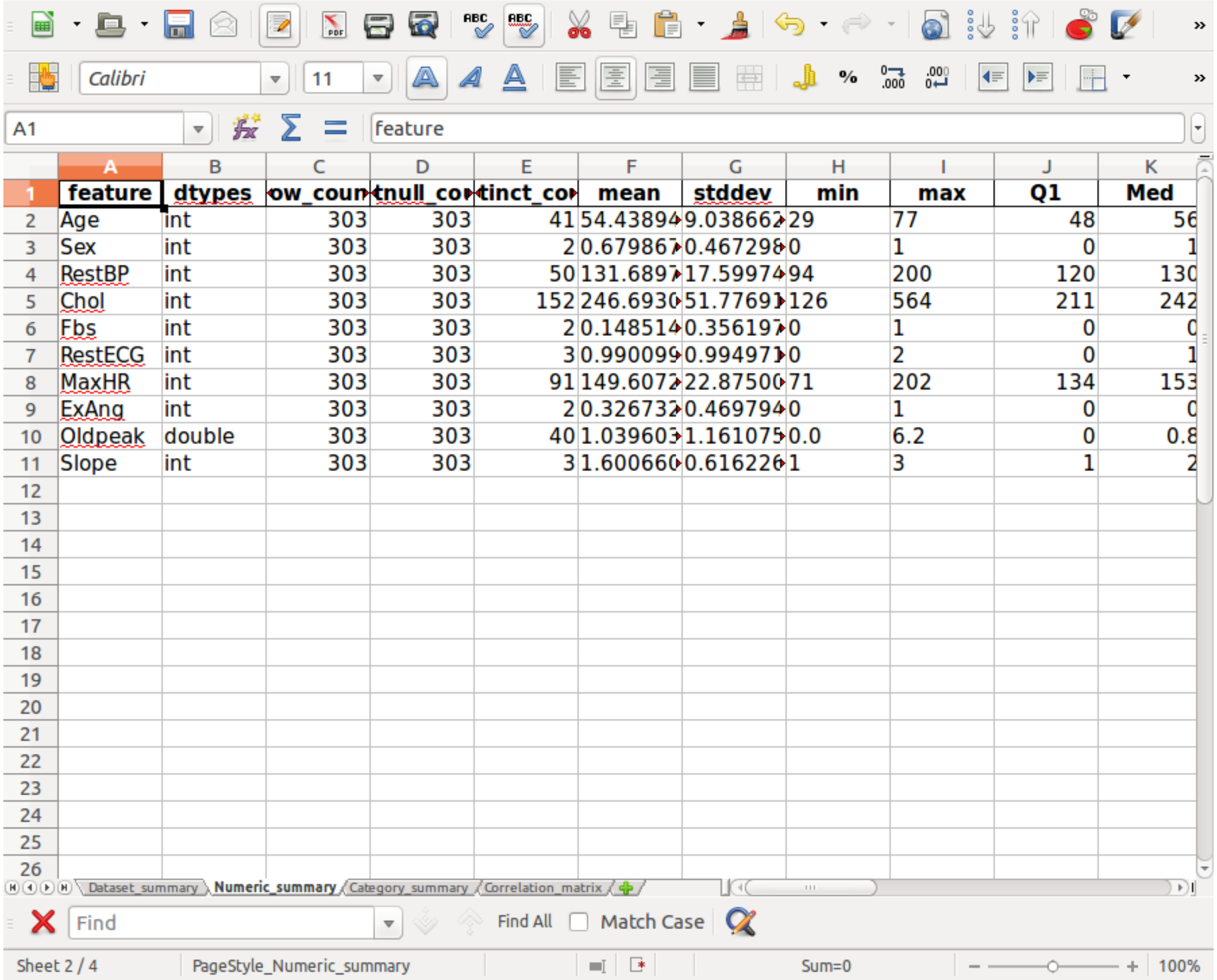
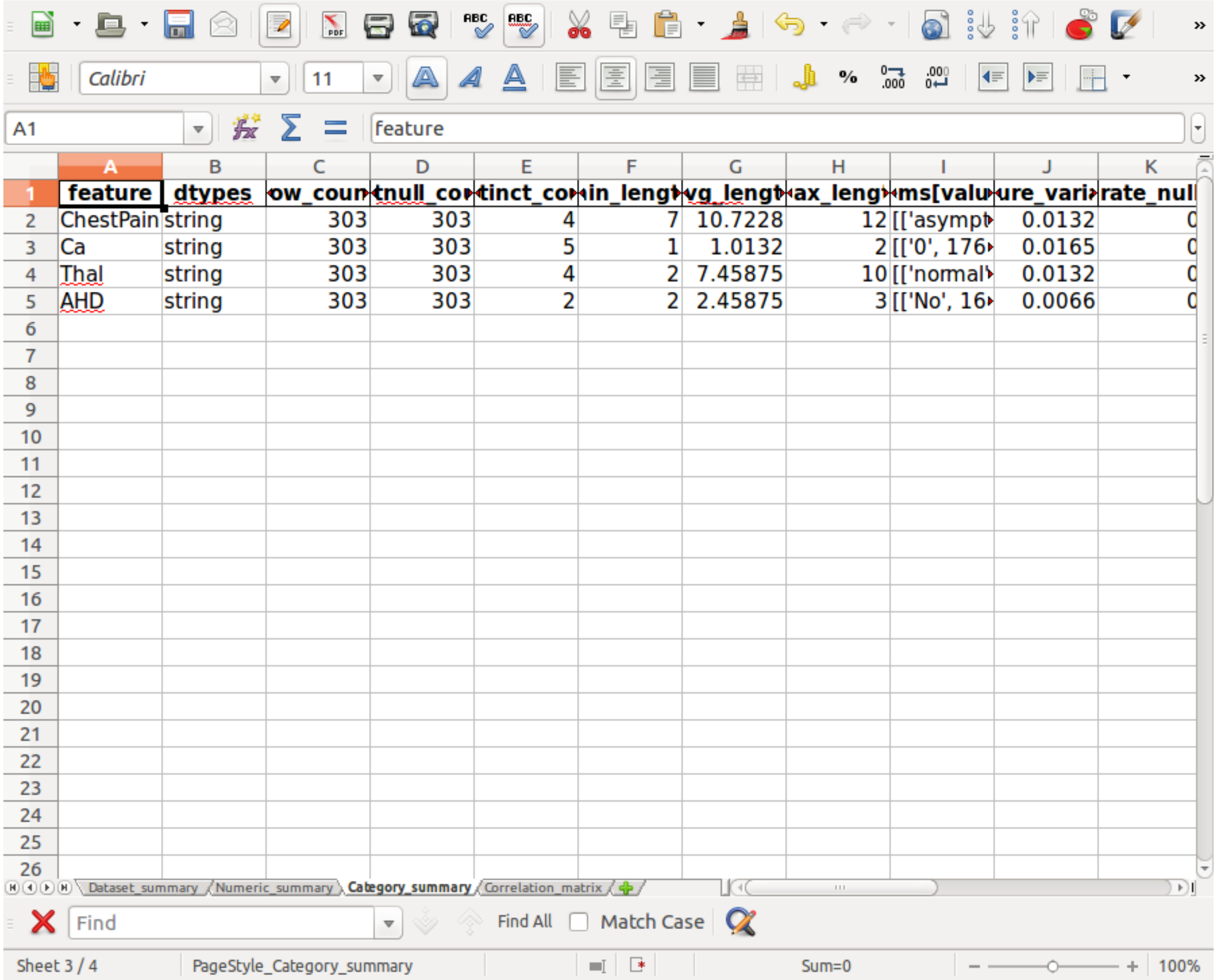


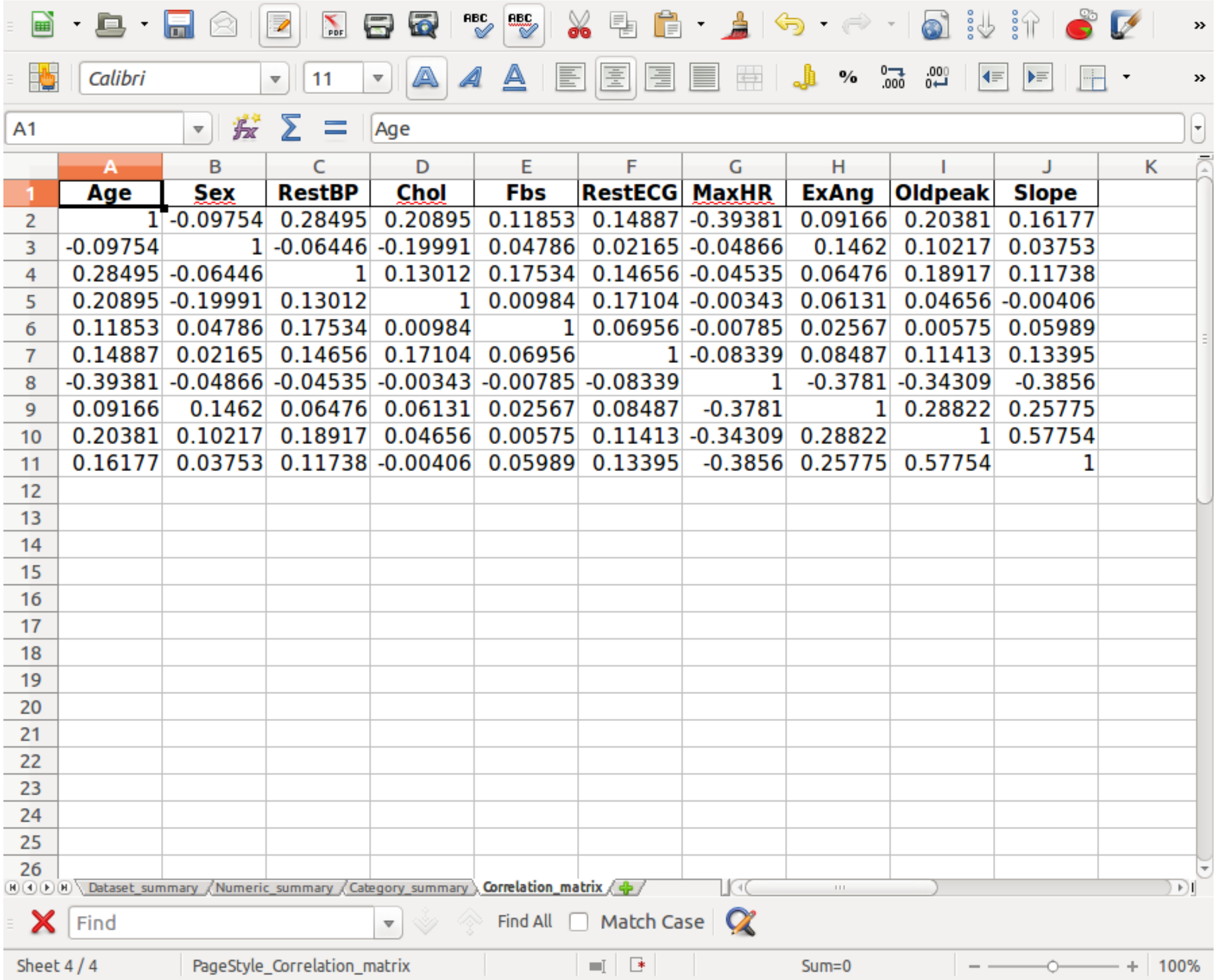
summary	value
sample_size	303
feature_size	14
single_unique_feature	0
row_w_null	0
row_w_empty	0
row_w_zero	299
row_avg_null_count	0
row_avg_empty_count	0
row_avg_zero_count	3.25083
numerical_fields	10
categorical_fields	4
date_fields	0
unsupported_fields	0
double	1
int	9
string	4



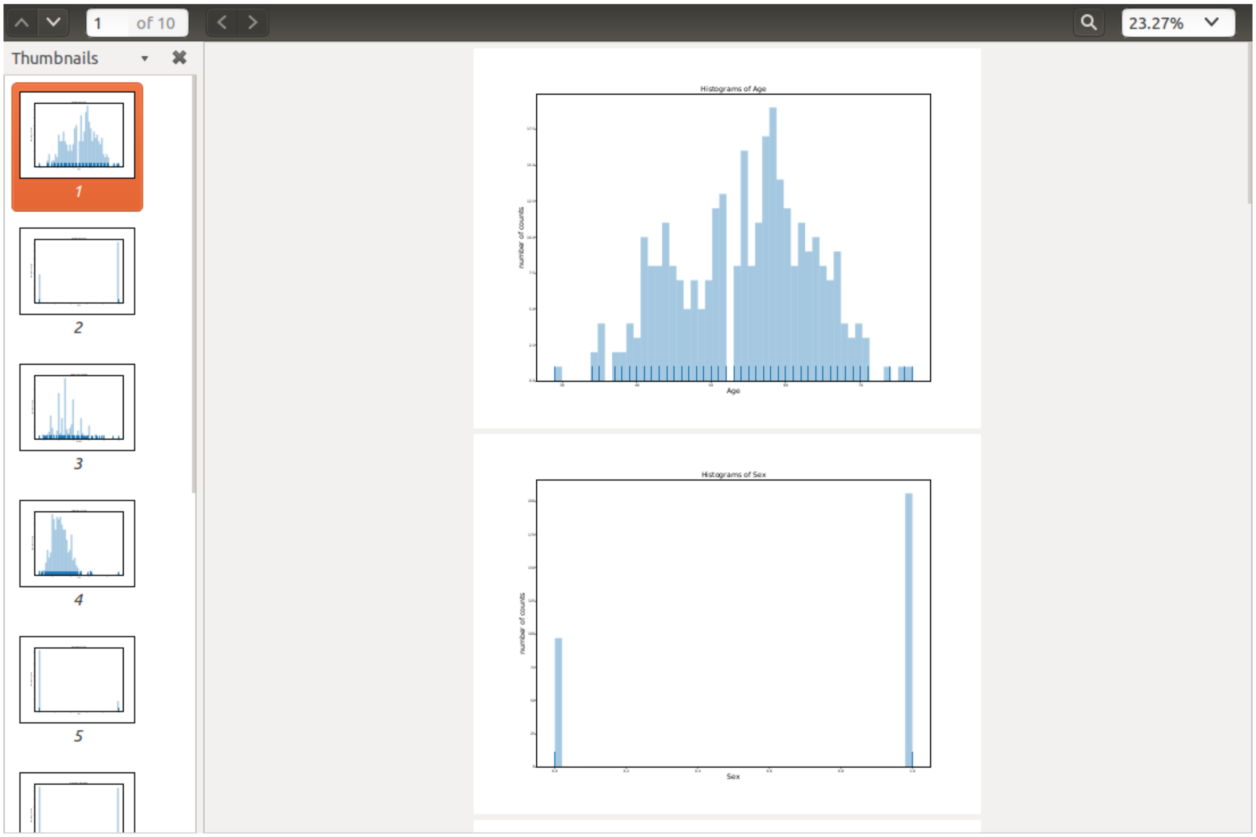
	A	B	C	D	E	F	G	H	I	J	K
1	feature	dtypes	ow_coun	tnull_co	tinct_co	mean	stddev	min	max	Q1	Med
2	Age	int	303	303	41	54.43894	9.038662	29	77	48	56
3	Sex	int	303	303	2	0.679867	0.467298	0	1	0	1
4	RestBP	int	303	303	50	131.6897	17.59974	94	200	120	130
5	Chol	int	303	303	152	246.6930	51.77691	126	564	211	242
6	Fbs	int	303	303	2	0.148514	0.356197	0	1	0	0
7	RestECG	int	303	303	3	0.990099	0.994971	0	2	0	1
8	MaxHR	int	303	303	91	149.6072	22.87500	71	202	134	153
9	ExAng	int	303	303	2	0.326732	0.469794	0	1	0	0
10	Oldpeak	double	303	303	40	1.039603	1.161075	0.0	6.2	0	0.8
11	Slope	int	303	303	3	1.600660	0.616226	1	3	1	2
12											
13											
14											
15											
16											
17											
18											
19											
20											
21											
22											
23											
24											
25											
26											

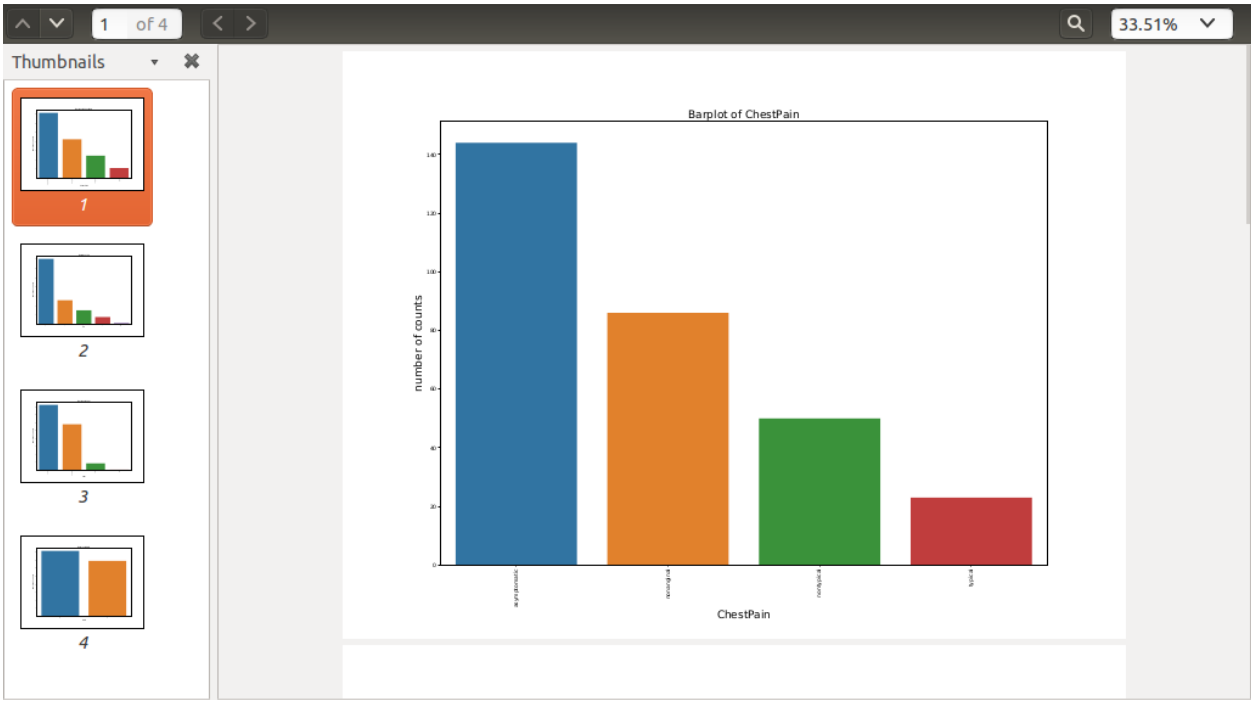


	A	B	C	D	E	F	G	H	I	J	K
1	feature	dtypes	ow_coun	tnull_co	tinct_co	in_lengt	vg_lengt	ax_leng	ms[valu	ure_vari	rate_nul
2	ChestPain	string	303	303	4	7	10.7228	12	[['asympt	0.0132	0
3	Ca	string	303	303	5	1	1.0132	2	[['0', 176	0.0165	0
4	Thal	string	303	303	4	2	7.45875	10	[['normal'	0.0132	0
5	AHD	string	303	303	2	2	2.45875	3	[['No', 16	0.0066	0



Age	Sex	RestBP	Chol	Fbs	RestECG	MaxHR	ExAng	Oldpeak	Slope
1	-0.09754	0.28495	0.20895	0.11853	0.14887	-0.39381	0.09166	0.20381	0.16177
-0.09754	1	-0.06446	-0.19991	0.04786	0.02165	-0.04866	0.1462	0.10217	0.03753
0.28495	-0.06446	1	0.13012	0.17534	0.14656	-0.04535	0.06476	0.18917	0.11738
0.20895	-0.19991	0.13012	1	0.00984	0.17104	-0.00343	0.06131	0.04656	-0.00406
0.11853	0.04786	0.17534	0.00984	1	0.06956	-0.00785	0.02567	0.00575	0.05989
0.14887	0.02165	0.14656	0.17104	0.06956	1	-0.08339	0.08487	0.11413	0.13395
-0.39381	-0.04866	-0.04535	-0.00343	-0.00785	-0.08339	1	-0.3781	-0.34309	-0.3856
0.09166	0.1462	0.06476	0.06131	0.02567	0.08487	-0.3781	1	0.28822	0.25775
0.20381	0.10217	0.18917	0.04656	0.00575	0.11413	-0.34309	0.28822	1	0.57754
0.16177	0.03753	0.11738	-0.00406	0.05989	0.13395	-0.3856	0.25775	0.57754	1


1 of 10
23.27%
Thumbnails
1
2
3
4
5
Histograms of Age
number of counts
Age
Histograms of Sex
number of counts
Sex


1 of 4
33.51%
Thumbnails
1
2
3
4
Barplot of ChestPain
number of counts
140
120
100
80
60
40
20
0
asymptomatic
nonanginal
nontypical
typical
ChestPain

(continued from previous page)

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        `""""`        `""""`     ;'
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CHAPTER

FIVE

MAIN REFERENCE

BIBLIOGRAPHY

[PyAudit] Wenqiang Feng and Ming Chen. Python Data Audit Library API, 2019.

[PySparkAudit] Wenqiang Feng and Yiming Xu. PySpark Data Audit Library API, 2019.