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Кафедра «Системы обработки информации и управления»

Лабораторная работа №2
по дисциплине
«Методы машинного обучения»
на тему
«Изучение библиотек обработки данных»

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0.1. Часть 1

Предварительно установим необходимые пакеты:

[0]:
```
!pip install -U seaborn
!pip install -U pandasql
```

Подключим пользователя к Google Drive:

[0]:
```
!pip install -U -q PyDrive
import os
from pydrive.auth import GoogleAuth
from pydrive.drive import GoogleDrive
from google.colab import auth
from oauth2client.client import GoogleCredentials
```

[0]:
```
# 1. Authenticate and create the PyDrive client.
auth.authenticate_user()
gauth = GoogleAuth()
gauth.credentials = GoogleCredentials.get_application_default()
drive = GoogleDrive(gauth)
```

[0]:
```
# choose a local (colab) directory to store the data.
local_download_path = os.path.expanduser('~/Files')
try:
  os.makedirs(local_download_path)
except: pass
```

[0]:
```
# 2. Auto-iterate using the query syntax
#    https://developers.google.com/drive/v2/web/search-parameters
file_list = drive.ListFile(
    {'q': "title='adult.dataset.csv'"}).GetList()
```

Подключим библиотеки для работы с датасетом:

[0]:
```
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
import pandasql as ps
%matplotlib inline
sns.set(style="ticks")
import warnings
warnings.filterwarnings('ignore')
```

[7]:
```
for f in file_list:
  # 3. Create & download by id.
  print('title: %s, id: %s' % (f['title'], f['id']))
  fname = os.path.join(local_download_path, f['title'])
  print('downloading to {}'.format(fname))
  f_ = drive.CreateFile({'id': f['id']})
  f_.GetContentFile(fname)
```

```
title: adult.dataset.csv, id: 1d9oaI8smgnh9JtdNmh30bc77CxoPyK-u
downloading to /root/Files/adult.dataset.csv
```

[8]:
```python
data = pd.read_csv(fname, sep=",")
data.head()
```

[8]:
```
   age         workclass  fnlwgt  education  education-num  \
0   39         State-gov   77516  Bachelors             13
1   50  Self-emp-not-inc   83311  Bachelors             13
2   38           Private  215646    HS-grad              9
3   53           Private  234721       11th              7
4   28           Private  338409  Bachelors             13

       marital-status         occupation   relationship   race     sex  \
0       Never-married       Adm-clerical  Not-in-family  White    Male
1  Married-civ-spouse    Exec-managerial        Husband  White    Male
2            Divorced  Handlers-cleaners  Not-in-family  White    Male
3  Married-civ-spouse  Handlers-cleaners        Husband  Black    Male
4  Married-civ-spouse     Prof-specialty           Wife  Black  Female

   capital-gain  capital-loss  hours-per-week native-country salary
0          2174             0              40  United-States  <=50K
1             0             0              13  United-States  <=50K
2             0             0              40  United-States  <=50K
3             0             0              40  United-States  <=50K
4             0             0              40           Cuba  <=50K
```

Выполнение непосредственно задач 1 части:

1. How many men and women (sex feature) are represented in this dataset?

(Как много мужчин и женщин представлено на датасете?)

[9]:
```python
data['sex'].value_counts()
```

[9]:
```
Male      21790
Female    10771
Name: sex, dtype: int64
```

2. What is the average age (age feature) of women?

(Какой средний возраст женщин?)

[10]:
```python
mean_age = data.loc[data['sex'] == 'Female', 'age'].mean()
print("Средний возраст: {0}".format(round(mean_age, 2)))
```

```
Средний возраст: 36.86
```

3. What is the percentage of German citizens (native-country feature)?

(Какой процент немецких граждан?)

[11]:
```python
percent = data.loc[data['native-country'] == 'Germany'].shape[0] * 100 /
    data.shape[0]
print("Процент немецких граждан: {0}%".format(round(percent, 4)))
```

```
Процент немецких граждан: 0.4207%
```

4-5. What are the mean and standard deviation of age for those who earn more than 50K per year (salary feature) and those who earn less than 50K per year?

(Какое среднее значение и среднее отклонение в возрасте у тех, кто зарабатывает >50k и тех, кто зарабатывает <=50k?)

[12]:
```python
more_than_fifty = data.loc[data['salary'] == '>50K', 'age']
less_than_fifty = data.loc[data['salary'] == '<=50K', 'age']

print("Средний возраст >50K:  {0} +- {1}".format
      (round(more_than_fifty.mean()), round(more_than_fifty.std(), 2)))
print("Средний возраст <=50K: {0} +- {1}".format
      (round(less_than_fifty.mean()), round(less_than_fifty.std(), 2)))
```

```
Средний возраст >50K:  44 +- 10.52
Средний возраст <=50K: 37 +- 14.02
```

6. Is it true that people who earn more than 50K have at least high school education? (education – Bachelors, Prof-school, Assoc-acdm, Assoc-voc, Masters or Doctorate feature)?

(Правда ли то, что люди, которые зарабатывают более 50k имеют как минимум школьное образование)

[13]:
```python
data.loc[data['salary'] == '>50K', 'education'].unique()
```

[13]:
```
array(['HS-grad', 'Masters', 'Bachelors', 'Some-college', 'Assoc-voc',
       'Doctorate', 'Prof-school', 'Assoc-acdm', '7th-8th', '12th',
       '10th', '11th', '9th', '5th-6th', '1st-4th'], dtype=object)
```

Так как есть значения '7th-8th', это утверждение неверно

7. Display age statistics for each race (race feature) and each gender (sex feature). Use groupby() and describe(). Find the maximum age of men of Amer-Indian-Eskimo race.

(Выведите статистику по возрасту для каждой расы и пола. Найдите максимальный возраст мужчины расы Amer-Indian-Eskimo)

[14]:
```python
for (race, sex), sub_data in data.groupby(['race', 'sex']):
    print("Race: {0}, sex: {1}".format(race, sex))
    print(sub_data['age'].describe())
    print()
```

```
Race: Amer-Indian-Eskimo, sex: Female
count    119.000000
mean      37.117647
std       13.114991
```

```
min       17.000000
25%       27.000000
50%       36.000000
75%       46.000000
max       80.000000
Name: age, dtype: float64

Race: Amer-Indian-Eskimo, sex: Male
count    192.000000
mean      37.208333
std       12.049563
min       17.000000
25%       28.000000
50%       35.000000
75%       45.000000
max       82.000000
Name: age, dtype: float64

Race: Asian-Pac-Islander, sex: Female
count    346.000000
mean      35.089595
std       12.300845
min       17.000000
25%       25.000000
50%       33.000000
75%       43.750000
max       75.000000
Name: age, dtype: float64

Race: Asian-Pac-Islander, sex: Male
count    693.000000
mean      39.073593
std       12.883944
min       18.000000
25%       29.000000
50%       37.000000
75%       46.000000
max       90.000000
Name: age, dtype: float64

Race: Black, sex: Female
count    1555.000000
mean       37.854019
std        12.637197
min        17.000000
25%        28.000000
50%        37.000000
75%        46.000000
max        90.000000
Name: age, dtype: float64
```

```
Race: Black, sex: Male
count    1569.000000
mean       37.682600
std        12.882612
min        17.000000
25%        27.000000
50%        36.000000
75%        46.000000
max        90.000000
Name: age, dtype: float64

Race: Other, sex: Female
count    109.000000
mean      31.678899
std       11.631599
min       17.000000
25%       23.000000
50%       29.000000
75%       39.000000
max       74.000000
Name: age, dtype: float64

Race: Other, sex: Male
count    162.000000
mean      34.654321
std       11.355531
min       17.000000
25%       26.000000
50%       32.000000
75%       42.000000
max       77.000000
Name: age, dtype: float64

Race: White, sex: Female
count    8642.000000
mean       36.811618
std        14.329093
min        17.000000
25%        25.000000
50%        35.000000
75%        46.000000
max        90.000000
Name: age, dtype: float64

Race: White, sex: Male
count    19174.000000
mean        39.652498
std         13.436029
min         17.000000
```

```
25%          29.000000
50%          38.000000
75%          49.000000
max          90.000000
Name: age, dtype: float64
```

[15]:
```
grouped_data = data.groupby(['race', 'sex'])
print("Максимальный возраст мужчин расы Amer-Indian-Eskimo: {0}"
      .format(grouped_data.get_group(('Amer-Indian-Eskimo','Male'))['age'].
 ↪max(0)))
```

```
Максимальный возраст мужчин расы Amer-Indian-Eskimo: 82
```

8. Among whom is the proportion of those who earn a lot (>50K) greater: married or single men (marital-status feature)? Consider as married those who have a marital-status starting with Married (Married-civ-spouse, Married-spouse-absent or Married-AF-spouse), the rest are considered bachelors.

(Какова доля женатых и неженатых мужчин с заработком >50k?)

[16]:
```
married_salary_stat = data.loc[(data['sex'] == 'Male') &
         (data['marital-status'].str.startswith('Married'))]
male_married = married_salary_stat.shape[0]
rich_married = married_salary_stat.loc[married_salary_stat['salary'] ==␣
 ↪'>50K'].shape[0]

bachelors_salary_stat = data.loc[(data['sex'] == 'Male') &
         ~(data['marital-status'].str.startswith('Married'))]
male_bachelors = bachelors_salary_stat.shape[0]
rich_bachelors = bachelors_salary_stat.loc[bachelors_salary_stat['salary']␣
 ↪== '>50K'].shape[0]

print("Доля женатых мужчин с заработком >50K: {0}%".
 ↪format(round(rich_married / male_married * 100, 2)))
print("Доля холостяков с заработком >50K: {0}%".
 ↪format(round(rich_bachelors / male_bachelors * 100, 2)))
```

```
Доля женатых мужчин с заработком >50K: 44.05%
Доля холостяков с заработком >50K: 8.45%
```

9. What is the maximum number of hours a person works per week (hours-per-week feature)? How many people work such a number of hours, and what is the percentage of those who earn a lot (>50K) among them?

(Какое максимальное число рабочих часов в неделю? Какое количество людей работает это число рабочих часов? Какова доля из этих людей, которые зарабатывают >50k?)

[17]:
```
max_load = data['hours-per-week'].max()
num_people_max_load = data[data['hours-per-week'] == max_load].shape[0]
proportion = data.loc[(data['hours-per-week'] == max_load)
                      & (data['salary'] == '>50K')].shape[0] /␣
 ↪num_people_max_load * 100

print("Максимальное количество рабочих часов в неделю: {0}".
 ↪format(max_load))
print("Количество людей, работающих {0} часов в неделю: {1}".
 ↪format(max_load, num_people_max_load))
print("Доля людей с большим заработком среди тех, кто работает {0} часов в␣
 ↪неделю: {1}%"
      .format(max_load, round(proportion, 2)))
```

```
Максимальное количество рабочих часов в неделю: 99
Количество людей, работающих 99 часов в неделю: 85
Доля людей с большим заработком среди тех, кто работает 99 часов в неделю:
29.41%
```

10. Count the average time of work (hours-per-week) for those who earn a little and a lot (salary) for each country (native-country). What will these be for Japan?

(Подсчитайте среднее число часов в неделю для богатых (>50k) и бедных (<=50k) в каждой стране. Какое будет значение для Японии?)

[18]:
```
pd.crosstab(data['native-country'], data['salary'],
            values=data['hours-per-week'], aggfunc=np.mean).T
```

[18]:
```
native-country          ?   Cambodia     Canada      China   Columbia  \
salary
<=50K           40.164760  41.416667  37.914634  37.381818  38.684211
>50K            45.547945  40.000000  45.641026  38.900000  50.000000

native-country       Cuba  Dominican-Republic    Ecuador  El-Salvador  \
salary
<=50K           37.985714           42.338235  38.041667    36.030928
>50K            42.440000           47.000000  48.750000    45.000000

native-country    England     …     Portugal  Puerto-Rico   Scotland  \
salary                        …
<=50K           40.483333     …    41.939394    38.470588  39.444444
>50K            44.533333     …    41.500000    39.416667  46.666667

native-country     South     Taiwan   Thailand  Trinadad&Tobago  \
salary
<=50K           40.15625  33.774194  42.866667        37.058824
>50K            51.43750  46.800000  58.333333        40.000000

native-country  United-States    Vietnam  Yugoslavia
salary
<=50K               38.799127  37.193548        41.6
```

```
>50K                45.505369  39.200000       49.5

[2 rows x 42 columns]
```

[19]:
```
japanese = data.loc[data['native-country'] == 'Japan']
for (country, salary), sub_df in japanese.groupby(['native-country',␣
 ↪'salary']):
    print(country, salary, round(sub_df['hours-per-week'].mean(), 2))
```

```
Japan <=50K 41.0
Japan >50K 47.96
```

0.2. Часть 2

[0]:
```
# After first 3 cells in part 1
file_list = drive.ListFile(
    {'q': "title contains 'mlm_lab2_2_'"}
).GetList()
```

[21]:
```
fnames = []
for f in file_list:
  # 3. Create & download by id.
  print('title: %s, id: %s' % (f['title'], f['id']))
  fnames.append(os.path.join(local_download_path, f['title']))
  print('downloading to {0}[{1}]'.format("fnames", len(fnames) - 1))
  f_ = drive.CreateFile({'id': f['id']})
  f_.GetContentFile(fnames[len(fnames) - 1])
```

```
title: mlm_lab2_2_user_usage.csv, id: 1_13razXeHU4QVE1pk9qRAW7RqkKb622H
downloading to fnames[0]
title: mlm_lab2_2_user_device.csv, id: 1lsiiarkA556JV_SCFb8YJKDnwmIDxk1x
downloading to fnames[1]
title: mlm_lab2_2_android_devices.csv, id: 1bcm-6KWZEAEmmYIFrsFd4w2oc06KOXWa
downloading to fnames[2]
```

[22]:
```
android_devices = pd.read_csv(fnames[2], sep=",")
android_devices.head()
```

[22]:

	Retail Branding	Marketing Name	Device	Model
0	NaN	NaN	AD681H	Smartfren Andromax AD681H
1	NaN	NaN	FJL21	FJL21
2	NaN	NaN	T31	Panasonic T31
3	NaN	NaN	hws7721g	MediaPad 7 Youth 2
4	3Q	OC1020A	OC1020A	OC1020A

[23]:
```
user_usage = pd.read_csv(fnames[0], sep=",")
user_usage.head()
```

[23]:
```
   outgoing_mins_per_month  outgoing_sms_per_month  monthly_mb  use_id
0                    21.97                    4.82     1557.33   22787
1                  1710.08                  136.88     7267.55   22788
2                  1710.08                  136.88     7267.55   22789
3                    94.46                   35.17      519.12   22790
4                    71.59                   79.26     1557.33   22792
```

[24]:
```
user_device = pd.read_csv(fnames[1], sep=",")
user_device.head()
```

[24]:
```
   use_id  user_id platform  platform_version     device  use_type_id
0   22782    26980      ios              10.2  iPhone7,2            2
1   22783    29628  android               6.0   Nexus 5            3
2   22784    28473  android               5.1   SM-G903F            1
3   22785    15200      ios              10.2  iPhone7,2            3
4   22786    28239  android               6.0  ONE E1003            1
```

0.2.1. Произвольный запрос на соединение двух наборов данных

- Pandas

[0]:
```
def join_pandas(user_usage, user_device):
    joined = pd.merge(user_usage,
                      user_device[['use_id', 'platform', 'device']],
                      on='use_id')
    return joined
```

[26]:
```
result = join_pandas(user_usage, user_device)
print("{0} записей".format(result.shape[0]))
result.head()
```

```
159 записей
```

[26]:
```
   outgoing_mins_per_month  outgoing_sms_per_month  monthly_mb  use_id  \
0                    21.97                    4.82     1557.33   22787
1                  1710.08                  136.88     7267.55   22788
2                  1710.08                  136.88     7267.55   22789
3                    94.46                   35.17      519.12   22790
4                    71.59                   79.26     1557.33   22792

  platform    device
0  android  GT-I9505
1  android  SM-G930F
2  android  SM-G930F
3  android     D2303
4  android  SM-G361F
```

- PandaSQL

[0]:
```python
# PandaSQL can't find datasets without arguments
def join_pandasql(user_usage, user_device):
  query = """SELECT
          use.*, dev.platform, dev.device
       FROM
          user_usage use
       JOIN
          user_device dev
             ON use.use_id = dev.use_id;"""

  return ps.sqldf(query, locals())
```

[28]:
```python
result = join_pandasql(user_usage, user_device)
print("{0} записей".format(result.shape[0]))
result.head()
```

```
159 записей
```

[28]:
```
   outgoing_mins_per_month  outgoing_sms_per_month  monthly_mb  use_id  \
0                    21.97                    4.82     1557.33   22787
1                  1710.08                  136.88     7267.55   22788
2                  1710.08                  136.88     7267.55   22789
3                    94.46                   35.17      519.12   22790
4                    71.59                   79.26     1557.33   22792

  platform    device
0  android  GT-I9505
1  android  SM-G930F
2  android  SM-G930F
3  android     D2303
4  android  SM-G361F
```

[0]:
```python
import time

def count_mean_time(func, params, N = 5):
    total_time = 0
    for i in range(N):
        time1 = time.time()
        if len(params) == 1:
            tmp_df = func(params[0])
        elif len(params) == 2:
            tmp_df = func(params[0], params[1])
        time2 = time.time()
        total_time += (time2 - time1)
    return total_time/N
```

- Оценка времени выполнения

[30]:
```
all_use_id = user_usage.use_id.unique().tolist()
len(all_use_id)
```

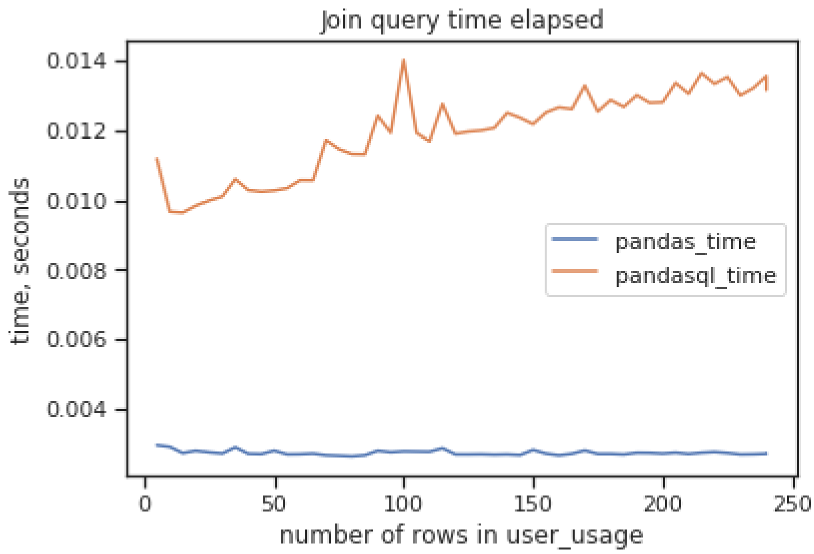
[30]: 240

[0]:
```
join_times = []
for use_id_count in range(5, 250, 5):
    use_ids = all_use_id[:use_id_count]
    user_usage_sample = user_usage[user_usage.use_id.isin(use_ids)]
    user_device_sample = user_device[user_device.use_id.isin(use_ids)]
    count = user_usage_sample.shape[0]
    pandasql_time = count_mean_time(join_pandasql, [user_usage_sample,␣
 ↪user_device_sample])
    pandas_time = count_mean_time(join_pandas, [user_usage_sample,␣
 ↪user_device_sample])
    join_times.append({'count': count, 'pandasql_time': pandasql_time,␣
 ↪'pandas_time': pandas_time})
```

[0]:
```
join_times_df = pd.DataFrame(join_times).set_index('count')
```

[33]:
```
ax = join_times_df.plot(title = 'Join query time elapsed')
ax.set_xlabel('number of rows in user_usage')
ax.set_ylabel('time, seconds')
```

[33]: Text(0, 0.5, 'time, seconds')



0.2.2. Произвольный запрос на группировку набора данных с использованием функций агрегирования

- Pandas

[0]:
```python
def aggregation_pandas(result):
  return result.groupby('platform', as_index=False).
 ↪agg({"outgoing_sms_per_month": "mean"})
```

[35]:
```python
agg_result = aggregation_pandas(result)
agg_result
```

[35]:
```
  platform  outgoing_sms_per_month
0  android               85.354586
1      ios              293.975000
```

- PandaSQL

[0]:
```python
def aggregation_pandasql(result):
  query = """SELECT
            platform,
            AVG(outgoing_sms_per_month) AS outgoing_sms_per_month
         FROM
            result
         GROUP BY platform;
         """

  return ps.sqldf(query, locals())
```

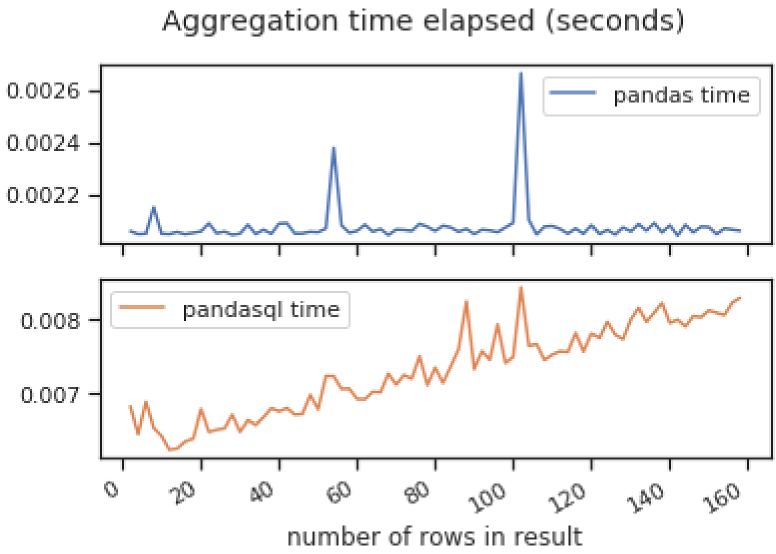
[37]:
```python
agg_result = aggregation_pandasql(result)
agg_result
```

[37]:
```
  platform  outgoing_sms_per_month
0  android               85.354586
1      ios              293.975000
```

[0]:
```python
aggregation_times = []
for count in range(2, 160, 2):
    pandasql_time = count_mean_time(aggregation_pandasql, [result[:count]])
    pandas_time = count_mean_time(aggregation_pandas, [result[:count]])
    aggregation_times.append({'count': count, 'pandasql_time':␣
 ↪pandasql_time, 'pandas_time': pandas_time})
```

[0]:
```python
aggregation_times_df = pd.DataFrame(aggregation_times)
aggregation_times_df.columns = ['number of rows in result', 'pandas time',␣
 ↪'pandasql time']
aggregation_times_df = aggregation_times_df.set_index('number of rows in␣
 ↪result')
```

[40]:
```python
ax = aggregation_times_df.plot(title = 'Aggregation time elapsed␣
 ↪(seconds)', subplots = True)
```



Aggregation time elapsed (seconds)
0.0026
0.0024
0.0022
pandas time
0.008
0.007
pandasql time
0
20
40
60
80
100
120
140
160
number of rows in result