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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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1. Цель работы

Цель лабораторной работы: изучение библиотек обработки данных Pandas и PandaSQL.

2. Задание

Часть 1.

- Выполните первое демонстрационное задание ”demo assignment” под названием ”Exploratory data analysis with Pandas” со страницы курса https://mlcourse.ai/assignments

Часть 2.

- Выполните следующие запросы с использованием двух различных библиотек - Pandas и PandaSQL:
- один произвольный запрос на соединение двух наборов данных
- один произвольный запрос на группировку набора данных с использованием функций агрегирования

3. Часть 1

Предварительно установим необходимые пакеты:

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

Подключим пользователя к Google Drive:

```
In [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
```

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

```
In [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
```

```
In [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:

```
In [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')
```

```
In [0]: 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
```

```
In [0]: data = pd.read_csv(fname, sep=",")
        data.head()
```

Out[0]:

	age	workclass	fnlwgt	education	education-num	marital-status	occupation	relationship	race	sex	capital-gain	capital-loss	hours-per-week	native-country	salary
0	39	State-gov	77516	Bachelors	13	Never-married	Adm-clerical	Not-in-family	White	Male	2174	0	40	United-States	<=50K
1	50	Self-emp-not-inc	83311	Bachelors	13	Married-civ-spouse	Exec-managerial	Husband	White	Male	0	0	13	United-States	<=50K
2	38	Private	215646	HS-grad	9	Divorced	Handlers-cleaners	Not-in-family	White	Male	0	0	40	United-States	<=50K
3	53	Private	234721	11th	7	Married-civ-spouse	Handlers-cleaners	Husband	Black	Male	0	0	40	United-States	<=50K
4	28	Private	338409	Bachelors	13	Married-civ-spouse	Prof-specialty	Wife	Black	Female	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?)

```
In [0]: data['sex'].value_counts()
```

```
Out[0]: Male      21790
        Female    10771
        Name: sex, dtype: int64
```

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

(Какой средний возраст женщин?)

```
In [0]: 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?)

```
In [0]: 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?)

```
In [0]: 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)

```
In [0]: data.loc[data['salary'] == '>50K', 'education'].unique()
```

```
Out[0]: 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)

```
In [0]: 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
```

```
In [0]: 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?)

```
In [0]: 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[

        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'].sha
```

```
print("Доля женатых мужчин с заработком >50K: {0}%".format(round(rich_married /
print("Доля холостяков с заработком >50K: {0}%".format(round(rich_bachelors / male_
```

```
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?)

```
In [0]: 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
        print("Доля людей с большим заработком среди тех, кто работает {0} часов в неделю:
            .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?)

```
In [0]: pd.crosstab(data['native-country'], data['salary'],
                    values=data['hours-per-week'], aggfunc=np.mean).T
```

```
Out[0]: 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]
```

```
In [0]: 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
```

4. Часть 2

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

```
In [0]: 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-6KWZEAEmmYIFrsFd4w2ocO6KOXWa
downloading to fnames[2]
```

```
In [0]: android_devices = pd.read_csv(fnames[2], sep=",")
        android_devices.head()
```

Out[0]:

	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

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

Out[0]:

	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

In [0]:
```
user_device = pd.read_csv(fnames[1], sep=",")
user_device.head()
```

Out[0]:

	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

4.0.1. Произвольный запрос на соединение двух наборов данных

- Pandas

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

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

159 записей

Out[0]:

	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

```
In [0]: # 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())

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

159 записей

```
Out[0]:    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
```

```
In [0]: 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

```
In [0]: all_use_id = user_usage.use_id.unique().tolist()
        len(all_use_id)
```

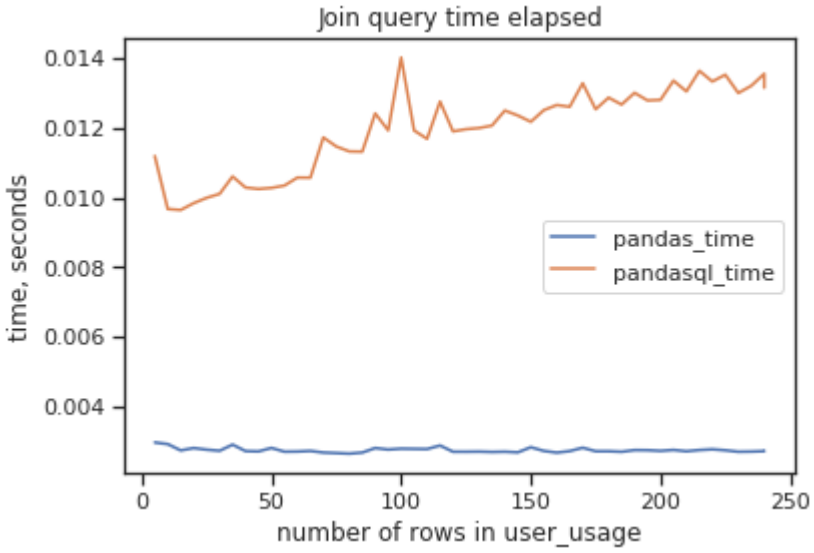
```
Out[0]: 240
```

```
In [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})
```

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

```
In [0]: ax = join_times_df.plot(title = 'Join query time elapsed')
        ax.set_xlabel('number of rows in user_usage')
        ax.set_ylabel('time, seconds')
```

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



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

- Pandas

```
In [0]: def aggregation_pandas(result):
            return result.groupby('platform', as_index=False).agg({"outgoing_sms_per_month": "m
```

```
In [0]: agg_result = aggregation_pandas(result)
        agg_result
```

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

- PandaSQL

```
In [0]: 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())
```

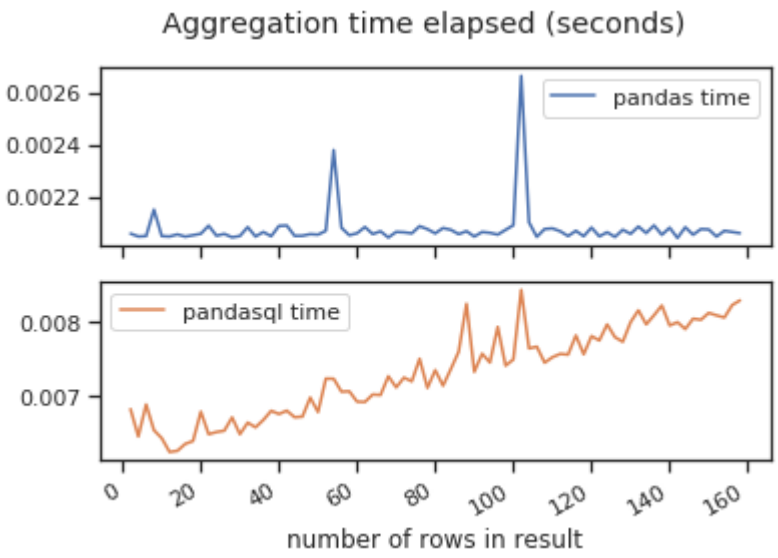
```
In [0]: agg_result = aggregation_pandasql(result)
        agg_result
```

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

```
In [0]: 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})
```

```
In [0]: 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')
```

```
In [0]: 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