

哈尔滨工业大学（深圳）

大数据实验指导书

实验二 数据理解、数据预处理及决策树的应用

1. 实验目的

1. 学会理解数据并对数据进行预处理；
2. 理解决策树的原理并掌握其构建方法。

2. 实验内容

1. 熟悉 Pandas 的安装和使用，并对数据进行预处理和可视化分析；
2. 熟悉 sklearn 包，调用决策树模型对数据进行训练。

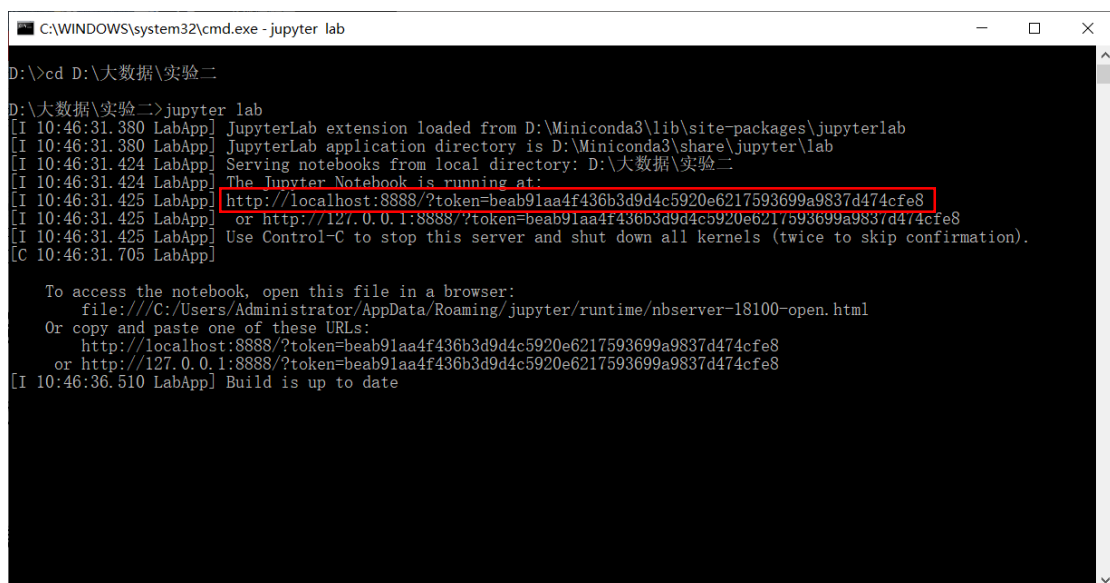
3. 实验环境

- Jupyter
- PyCharm

4. 实验步骤

4.1 启动 jupyter

通过 cmd，进入到实验二的目录下，输入 `jupyter lab` 后，会弹出 jupyter 的操作页面，若未弹出则复制红框中的 url 到浏览器中。



```
C:\WINDOWS\system32\cmd.exe - jupyter lab
D:\>cd D:\大数据\实验二
D:\大数据\实验二>jupyter lab
[I 10:46:31.380 LabApp] JupyterLab extension loaded from D:\Miniconda3\lib\site-packages\jupyterlab
[I 10:46:31.380 LabApp] JupyterLab application directory is D:\Miniconda3\share\jupyter\lab
[I 10:46:31.424 LabApp] Serving notebooks from local directory: D:\大数据\实验二
[I 10:46:31.424 LabApp] The Jupyter Notebook is running at:
[I 10:46:31.425 LabApp] http://localhost:8888/?token=beab91aa4f436b3d9d4c5920e6217593699a9837d474cfe8
[I 10:46:31.425 LabApp] or http://127.0.0.1:8888/?token=beab91aa4f436b3d9d4c5920e6217593699a9837d474cfe8
[I 10:46:31.425 LabApp] Use Control-C to stop this server and shut down all kernels (twice to skip confirmation).
[C 10:46:31.705 LabApp]

To access the notebook, open this file in a browser:
file:///C:/Users/Administrator/AppData/Roaming/jupyter/runtime/nbserver-18100-open.html
Or copy and paste one of these URLs:
http://localhost:8888/?token=beab91aa4f436b3d9d4c5920e6217593699a9837d474cfe8
or http://127.0.0.1:8888/?token=beab91aa4f436b3d9d4c5920e6217593699a9837d474cfe8
[I 10:46:36.510 LabApp] Build is up to date
```

4.2 安装 Pandas 库并熟悉其基本操作

Pandas 是 python 第三方库，提供高性能易用数据类型和分析工具。Pandas 基于 numpy 实现，常与 numpy 和 matplotlib 一同使用，更多学习请参考 pandas 中文网：<https://www.py pandas. cn/>。

4.2.1 安装 Pandas 库

打开 cmd 命令行窗口执行：

```
pip install pandas
```

4.2.2 Pandas 核心数据结构

维数	名称	描述
1	Series	带标签的一维同构数组
2	DataFrame	带标签的，大小可变的，二维异构表格

Series 是带标签的一维数组，可存储整数、浮点数、字符串、Python 对象等类型的数据。轴标签统称为索引。Series 中只允许存储相同的数据类型，这样可以更有效的使用内存，提高运算效率。调用 `pd.Series` 函数即可创建 Series。

DataFrame 是一个表格型的数据结构，类似于 Excel 或 sql 表，它含有一组有序的列，每列可以是不同的值类型（数值、字符串、布尔值等）。DataFrame 既有行索引也有列索引，它可以被看做由 Series 组成的字典（共用同一个索引），可用多维数组字典、列表字典生成 DataFrame。

4.2.3 Pandas 库基本操作

(1) 生成数据

```
[5]: import numpy as np
import pandas as pd
data = {'A': [1,2,3], 'B': [4,5,6], 'C': [7,8,9]}
df = pd.DataFrame(data)
print(df)
```

```
   A  B  C
0  1  4  7
1  2  5  8
2  3  6  9
```

(2) 计算数据的基本信息

```
[7]: df.describe()
```

```
[7]:
```

	A	B	C
count	3.0	3.0	3.0
mean	2.0	5.0	8.0
std	1.0	1.0	1.0
min	1.0	4.0	7.0
25%	1.5	4.5	7.5
50%	2.0	5.0	8.0
75%	2.5	5.5	8.5
max	3.0	6.0	9.0

(3) 选取特定列

```
df[['A', 'C']]
```

	A	C
0	1	7
1	2	8
2	3	9

(4) 选取特定列行

```
df.iloc[[1,2]]
```

	A	B	C
1	2	5	8
2	3	6	9

(5) 选取多行多列

```
df.iloc[[1,2],[0,2]]
```

	A	C
1	2	8
2	3	9

(6) 选取 B 列大于等于 5 的数据

```
df[df['B'] >= 5]
```

	A	B	C
1	2	5	8
2	3	6	9

(7) 修改指定列

```
df['B'] = 0
print(df)
```

	A	B	C
0	1	0	7
1	2	0	8
2	3	0	9

4.3 数据读取及预处理

4.3.1 读取数据

(1) 读取 csv 文件并获取所有的表头

```
import numpy as np
import pandas as pd
import matplotlib
import matplotlib.pyplot as plt

df = pd.read_csv("D:/大数据/实验二/bank.csv")
cols = df.columns.values
cols = [col.replace('\\', '') for col in cols[0].split(';')]
print(cols)
```

['age', 'job', 'marital', 'education', 'default', 'balance', 'housing', 'loan', 'contact', 'day', 'month', 'duration', 'campaign', 'pdays', 'previous', 'poutcome', 'y']

属性	描述	类型	缺失值
age	年龄	数值	无
job	工作类型	分类	unknown
marital	婚姻状况	分类	无
education	受教育程度	分类	unknown
default	是否存在拖欠	分类	无
balance	平均年度余额（欧元）	数值	无
housing	是否有住房贷款	分类	无
loan	是否有个人贷款	分类	无
contact	联络方式	分类	unknown
day	最后一次联系是几号	数值	无
month	最后一次联系的月份	分类	无
duration	最后一次联系的持续时间（秒）	数值	无

属性	描述	类型	缺失值
campaign	此营销活动期间和此客户联系的次数，包括最后一次联系	数值	无
pdays	从上一个营销活动最后一次联系客户后经过的天数，-1表示之前未联系过客户	数值	无
previous	此营销活动之前和此客户联系的次数	数值	无
poutcome	上一次营销活动的结果	分类	unknown
y	客户是否将订购银行定期存款	分类	无

(2) 获取所有的数据并转为二维数组的形式

```
datas = []
for i in range(len(df)):
    s = df.iloc[i].values[0]
    datas.append([item.replace('\n', '') for item in s.split(';')])
datas = np.array(datas)
print(datas)

[['30' 'unemployed' 'married' ... '0' 'unknown' 'no']
 ['33' 'services' 'married' ... '4' 'failure' 'no']
 ['35' 'management' 'single' ... '1' 'failure' 'no']
 ...
 ['57' 'technician' 'married' ... '0' 'unknown' 'no']
 ['28' 'blue-collar' 'married' ... '3' 'other' 'no']
 ['44' 'entrepreneur' 'single' ... '7' 'other' 'no']]
```

(3) 将数据与表头转化为 DataFrame 格式

```
df_frame = {}
for i in range(len(cols)):
    df_frame[cols[i]] = datas[:,i]
df = pd.DataFrame(df_frame)
print(df)
```

	age	job	marital	education	default	...	campaign	pdays	previous	poutcome	y
0	30	unemployed	married	primary	no	...	1	-1	0	unknown	no
1	33	services	married	secondary	no	...	1	339	4	failure	no
...
4519	28	blue-collar	married	secondary	no	...	4	211	3	other	no
4520	44	entrepreneur	single	tertiary	no	...	2	249	7	other	no

[4521 rows x 17 columns]

(4) 将以下列从字符类型转为整数类型

```
df[['age', 'balance', 'duration', 'campaign', 'pdays', 'previous']] = df[['age', 'balance', 'duration', 'campaign', 'pdays', 'previous']].astype(int)
df.dtypes
```

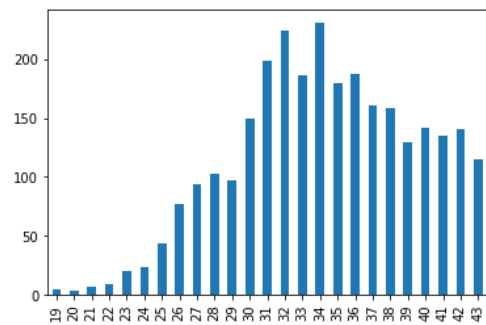
```
age          int32
job          object
marital      object
education    object
default      object
balance      int32
housing      object
loan         object
contact      object
day          object
month        object
duration     int32
campaign     int32
pdays      int32
previous     int32
poutcome    object
y           object
Length: 17, dtype: object
```

(5) 数据可视化

绘制柱状图：

```
df['age'].value_counts().sort_index().head(25).plot.bar()
```

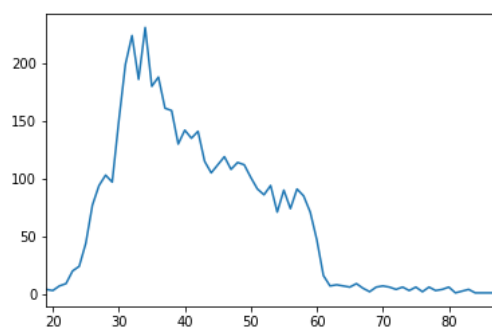
<AxesSubplot:>



绘制折线图:

```
df['age'].value_counts().sort_index().plot.line()
```

<matplotlib.axes._subplots.AxesSubplot at 0x247287b8be0>



4.3.2 数据预处理

(1) 筛选重复值并删除

```
df.duplicated()
```

```
0      False
1      False
2      False
3      False
4      False
...
4516   False
4517   False
4518   False
4519   False
4520   False
Length: 4521, dtype: bool
```

```
df.drop_duplicates()
```

	age	job	marital	education	default	balance	housing	loan	contact	day	month	duration	campaign	pdays	previous	outcome	y
0	30	unemployed	married	primary	no	1787	no	no	cellular	19	oct	79	1	-1	0	unknown	no
1	33	services	married	secondary	no	4789	yes	yes	cellular	11	may	220	1	339	4	failure	no
2	35	management	single	tertiary	no	1350	yes	no	cellular	16	apr	185	1	330	1	failure	no
3	30	management	married	tertiary	no	1476	yes	yes	unknown	3	jun	199	4	-1	0	unknown	no
4	59	blue-collar	married	secondary	no	0	yes	no	unknown	5	may	226	1	-1	0	unknown	no
...
4516	33	services	married	secondary	no	-333	yes	no	cellular	30	jul	329	5	-1	0	unknown	no
4517	57	self-employed	married	tertiary	yes	-3313	yes	yes	unknown	9	may	153	1	-1	0	unknown	no
4518	57	technician	married	secondary	no	295	no	no	cellular	19	aug	151	11	-1	0	unknown	no
4519	28	blue-collar	married	secondary	no	1137	no	no	cellular	6	feb	129	4	211	3	other	no
4520	44	entrepreneur	single	tertiary	no	1136	yes	yes	cellular	3	apr	345	2	249	7	other	no

(2) 将 yes/no 分类映射为 0/1 分类

```
class_mapping = {'no':0, 'yes':1}
df['default'] = df['default'].map(class_mapping)
df['housing'] = df['housing'].map(class_mapping)
df['loan'] = df['loan'].map(class_mapping)
df['y'] = df['y'].map(class_mapping)
```

	y	default	housing	loan		y	default	housing	loan
0	no	no	no	no	0	0	0	0	0
1	no	no	yes	yes	1	0	0	1	1
2	no	no	yes	no	2	0	0	1	0
3	no	no	yes	yes	3	0	0	1	1
4	no	no	yes	no	4	0	0	1	0
...
4516	no	no	yes	no	4516	0	0	1	0
4517	no	yes	yes	yes	4517	0	1	1	1
4518	no	no	no	no	4518	0	0	0	0
4519	no	no	no	no	4519	0	0	0	0
4520	no	no	yes	yes	4520	0	0	1	1

(3) 将月份和日期转化成距离现在的天数

```
month_dict = {'oct': '10', 'may': '05', 'apr': '04', 'jun': '06', 'feb': '02', 'aug': '08',
              'jan': '01', 'jul': '07', 'nov': '11', 'sep': '09', 'mar': '03', 'dec': '12'}
df['month'] = df['month'].map(month_dict)
df['date'] = '2019' + '-' + df['month'] + '-' + df['day']
df['date'] = pd.to_datetime(df['date'], format='%Y-%m-%d')
df['date'] = pd.to_datetime('2020-01-01', format='%Y-%m-%d') - df['date']
df['date'] = df['date'].dt.days
print(df['date'])
```

```
0      74
1     235
2     260
3     212
4     241
...
4516   155
4517   237
4518   135
4519   329
4520   273
Name: date, Length: 4521, dtype: int64
```

(4) 删除原有的月份与日期

```
del(df['day'])
del(df['month'])
```

(5) 将字符型分类变量转化为数值型并处理缺失值

```
jobs = df['job'].unique()
job_mapping = {jobs[i]: i for i in range(jobs.shape[0])}

maritals = df['marital'].unique()
marital_mapping = {maritals[i]: i for i in range(maritals.shape[0])}

educations = df['education'].unique()
education_mapping = {educations[i]: i for i in range(educations.shape[0])}

contacts = df['contact'].unique()
contact_mapping = {contacts[i]: i for i in range(contacts.shape[0])}

poutcomes = df['poutcome'].unique()
poutcome_mapping = {poutcomes[i]: i for i in range(poutcomes.shape[0])}

df['marital'] = df['marital'].map(marital_mapping)
df['job'] = df['job'].map(job_mapping)
df['education'] = df['education'].map(education_mapping)
df['contact'] = df['contact'].map(contact_mapping)
df['poutcome'] = df['poutcome'].map(poutcome_mapping)
df
```


	age	job	marital	education	default	balance	housing	loan	contact	duration	campaign	pdays	previous	poutcome	y	date
0	30	0	0	0	0	1787	0	0	0	79	1	-1	0	0	0	74
1	33	1	0	1	0	4789	1	1	0	220	1	339	4	1	0	235
2	35	2	1	2	0	1350	1	0	0	185	1	330	1	1	0	260
3	30	2	0	2	0	1476	1	1	1	199	4	-1	0	0	0	212
4	59	3	0	1	0	0	1	0	1	226	1	-1	0	0	0	241
...
4516	33	1	0	1	0	-333	1	0	0	329	5	-1	0	0	0	155
4517	57	4	0	2	1	-3313	1	1	1	153	1	-1	0	0	0	237
4518	57	5	0	1	0	295	0	0	0	151	11	-1	0	0	0	135
4519	28	3	0	1	0	1137	0	0	0	129	4	211	3	2	0	329
4520	44	6	1	2	0	1136	1	1	0	345	2	249	7	2	0	273

4521 rows x 16 columns

(6) 将以下两列的数据离散化

分箱：

```
bins = [18, 25, 35, 45, 55, 100] # 指定年龄的分界点
df['age'] = pd.cut(df['age'], bins, labels=False)
bins = [-np.inf, 4137.1, 11587.2, np.inf]
df['balance'] = pd.cut(df['balance'], bins, labels=False)
print(df[['age', 'balance']])
```

```
   age  balance
0     1         0
1     1         1
2     1         0
3     1         0
4     4         0
...   ...     ...
4516  1         0
4517  4         0
4518  4         0
4519  1         0
4520  2         0
```

(7) 将以下四列的数据归一化

```
cols = ['pdays', 'duration', 'campaign', 'date']
for col in cols:
    df[col] = (df[col] - df[col].min()) / (df[col].max() - df[col].min())
print(df[['pdays', 'duration', 'campaign', 'date']])
```

```
   pdays  duration  campaign   date
0  0.000000  0.024826  0.000000  0.203911
1  0.389908  0.071500  0.000000  0.653631
2  0.379587  0.059914  0.000000  0.723464
3  0.000000  0.064548  0.061224  0.589385
4  0.000000  0.073486  0.000000  0.670391
...   ...     ...     ...     ...
4516  0.000000  0.107580  0.081633  0.430168
4517  0.000000  0.049321  0.000000  0.659218
4518  0.000000  0.048659  0.204082  0.374302
4519  0.243119  0.041377  0.061224  0.916201
4520  0.286697  0.112877  0.020408  0.759777
```

[4521 rows x 4 columns]

(8) 保存数据

```
df.to_csv('D:/大数据/实验二/after_bank.csv')
df
```

	age	job	marital	education	default	balance	housing	loan	contact	duration	campaign	pdays	previous	poutcome	y	date
0	1	0	0	0	0	0	0	0	0	0.024826	0.000000	0.000000	0	0	0	0.203911
1	1	1	0	1	0	1	1	1	0	0.071500	0.000000	0.389908	4	1	0	0.653631
2	1	2	1	2	0	0	1	0	0	0.059914	0.000000	0.379587	1	1	0	0.723464
3	1	2	0	2	0	0	1	1	1	0.064548	0.061224	0.000000	0	0	0	0.589385
4	4	3	0	1	0	0	1	0	1	0.073486	0.000000	0.000000	0	0	0	0.670391
...
4516	1	1	0	1	0	0	1	0	0	0.107580	0.081633	0.000000	0	0	0	0.430168
4517	4	4	0	2	1	0	1	1	1	0.049321	0.000000	0.000000	0	0	0	0.659218
4518	4	5	0	1	0	0	0	0	0	0.048659	0.204082	0.000000	0	0	0	0.374302
4519	1	3	0	1	0	0	0	0	0	0.041377	0.061224	0.243119	3	2	0	0.916201
4520	2	6	1	2	0	0	1	1	0	0.112877	0.020408	0.286697	7	2	0	0.759777

4521 rows x 16 columns

4.4 安装 sklearn 并构建决策树

决策树是一种树形结构的分类器，通过顺序询问分类点的属性决定分类点最终类别。通常根据特征的信息增益或其他指标，构建一棵决策树。

4.4.1 安装 sklearn

```
D:\大数据\实验二>pip install scikit-learn
```

4.4.2 读取数据

```
from sklearn.tree import DecisionTreeClassifier as DTC, export_graphviz
# 读取数据
df = pd.read_csv('D:/大数据/实验二/after_bank.csv')
df = df.iloc[:,1:]
cols = list(df.columns.values)
cols.remove('y')
X = df[cols]
y = df[['y']]
```

4.4.3 划分训练集和测试集

```
# 划分训练集与测试集
X_train = X[:4000]
y_train = y[:4000]
X_test = X[4000:5000]
y_test = y[4000:5000]
```

4.4.4 训练模型

```
dtc = DTC(criterion='entropy', max_depth=5) # 基于信息熵
dtc.fit(X_train, y_train)
print('准确率: ', dtc.score(X_test, y_test))
```

准确率: 0.8886756238003839

4.4.5 参数调整

构建模型中很重要的一步是**调参**。在 sklearn 中, 模型的参数是通过方法参数来决定的, 以下给出 sklearn 中, 决策树的参数:

```
DecisionTreeClassifier(criterion="gini",
                       splitter="best",
                       max_depth=None,
                       min_samples_split=2,
                       min_samples_leaf=1,
                       min_weight_fraction_leaf=0.,
                       max_features=None,
                       random_state=None,
                       max_leaf_nodes=None,
                       min_impurity_decrease=0.,
                       min_impurity_split=None,
                       class_weight=None,
                       presort=False)
```

通常来说, 较为重要的参数有:

criterion: 用以设置用信息熵还是基尼系数计算

string, optional (default="gini")

- (1).criterion='gini',分裂节点时评价准则是 Gini 指数。
- (2).criterion='entropy',分裂节点时的评价指标是信息增益。

splitter: 指定分支模式

string, optional (default="best")。指定分裂节点时的策略。

- (1).splitter='best',表示选择最优的分裂策略。
- (2).splitter='random',表示选择最好的随机切分策略。

max_depth: 最大深度, 防止过拟合

int or None, optional (default=None)。指定树的最大深度。

如果为 None, 表示树的深度不限。直到所有的叶子节点都是纯净的, 即叶子节点中所有的样本点都属于同一个类别。或者每个叶子节点包含的样本数小于 min_samples_split。

min_samples_leaf: 限定每个节点分枝后子节点至少有多少个数据, 否则就不分枝

int, float, optional (default=2)。表示分裂一个内部节点需要的最少样本数。

- (1).如果为整数, 则 min_samples_split 就是最少样本数。
- (2).如果为浮点数(0 到 1 之间), 则每次分裂最少样本数为 $\text{ceil}(\text{min_samples_split} * n_samples)$

(1) 采用基尼系数替换信息熵对结果的影响:

```
dtc = DTC(criterion='gini', max_depth=5) # 基于基尼系数
dtc.fit(X_train, y_train)
print('准确率: ', dtc.score(X_test, y_test))
```

准确率: 0.8925143953934741

(2) 采用不同的树的深度, 对结果的影响

```
for depth in range(1, 10):
    dtc = DTC(criterion='entropy', max_depth=depth) # 基于信息熵
    dtc.fit(X_train, y_train)
    print('depth:', depth, '|', '准确率:', dtc.score(X_test, y_test))
```

depth: 1 | 准确率: 0.8790786948176583
depth: 2 | 准确率: 0.8733205374280231
depth: 3 | 准确率: 0.8963531669865643
depth: 4 | 准确率: 0.9001919385796545
depth: 5 | 准确率: 0.9001919385796545
depth: 6 | 准确率: 0.8905950095969289
depth: 7 | 准确率: 0.8905950095969289
depth: 8 | 准确率: 0.8867562380038387
depth: 9 | 准确率: 0.8848368522072937

4.4.5 可视化决策树模型

(1) 安装 Graphviz

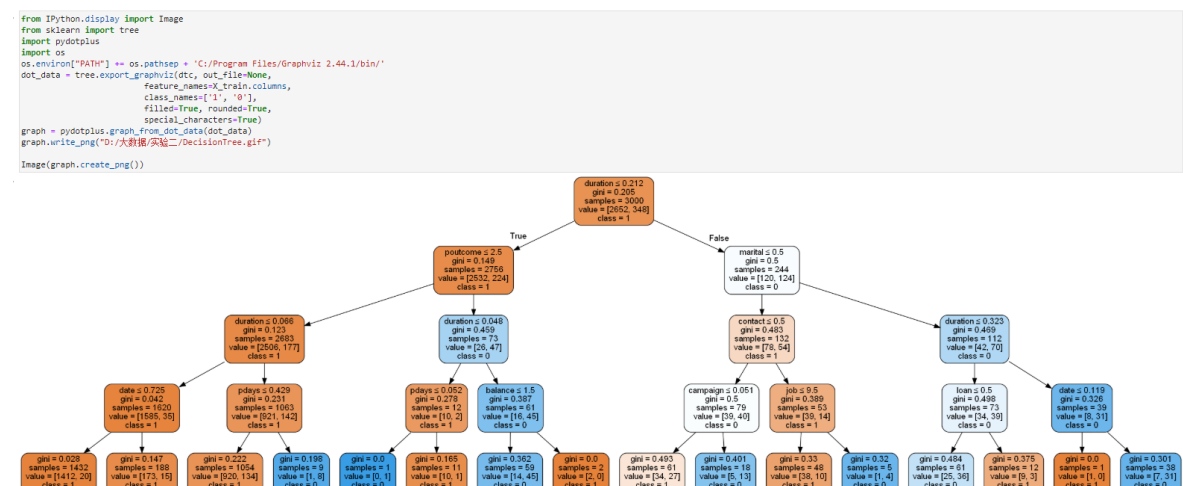
下载 graphviz-install-2.44.1-win64.exe 并安装, 下载地址:

<https://www2.graphviz.org/Packages/stable/windows/10/cmake/Release/x64/>

(2) 安装 pydotplus

```
pip install pydotplus
```

(3) 绘制决策树模型



绘制决策树时，如果遇到：

InvocationException: Program terminated with status: 1. stderr follows: Format: "png" not recognized. Use one of:

可用管理员身份运行 cmd，执行

```
C:\Windows\system32>cd c:/  
c:\>cd Program Files\Graphviz 2.44.1\bin  
c:\Program Files\Graphviz 2.44.1\bin>dot -c  
c:\Program Files\Graphviz 2.44.1\bin>_
```