

## 第 6 次课 字典和字符串

Python 科学计算

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### 提要

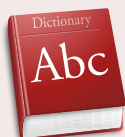
#### 1 字典

#### 2 字符串

### 字典

```
import os
figs = {'fig1.pdf': 81761, 'fig2.png': 8754}
figs['NBU.pdf'] = os.path.getsize('figures/NBU.pdf')
for name in figs:
    print('文件 %8s 的大小是 %5d' % \
          (name, figs[name]))
```

```
>>>
文件 fig1.pdf 的大小是 81761
文件 fig2.png 的大小是 8754
文件 NBU.pdf 的大小是 7967
```



### 字典可以看作一种广义上的列表

#### 列表特性

- 列表中存储着一系列的元素
- 每个元素都是一个 Python 对象
- 通过序号（从 0 开始）访问每一个元素

#### 字典

- 可以通过文本（词）索引对象
- Python 的字典在其它语言中也叫 Hash 表、Hash 映射、关联数组

## 使用字典建立映射关系

使用列表有时候会不自然

```
>>> temps = [34.3, 26.7, 32.5] # 宁波、北京、上海的气温
>>> print('宁波的温度: %.1f' % temps[0])
宁波的温度: 34.3
```

使用字典可以是城市和温度对应起来

```
>>> temps = {'宁波': 34.3, '北京': 26.7, '上海': 32.5}
>>> print('宁波的温度: %.1f' % temps['宁波'])
宁波的温度: 34.3
```

- 在字典中充当索引的称键 (key)，使用键访问的叫值 (value)。
- 在上面的例子中，'宁波' 是键，34.3 是值。
- 字典是无序键-值对集合，通过键访问值: value = dictionary[key]

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2024 年 9 月 1 日

5 / 37

Notes

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## 字典的初始化

两种初始化方法

```
>>> temps = {'nb': 34.3, 'bj': 26.7, 'sh': 32.5}
>>> temps
{'nb': 34.3, 'bj': 26.7, 'sh': 32.5}
>>> temps = dict(nb = 34.3, bj = 26.7, sh = 32.5)
>>> temps
{'nb': 34.3, 'bj': 26.7, 'sh': 32.5}
```

往字典中增加一个元素

```
>>> temps['hk'] = 30.5
>>> temps
{'nb': 34.3, 'bj': 26.7, 'sh': 32.5, 'hk': 30.5}
>>> temps['hk']
30.5
```

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2024 年 9 月 1 日

6 / 37

Notes

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## 循环操作字典：对键的循环

```
>>> for city in temps:
...     print('%s 的温度是 %g C' % (city, temps[city]))
...
nb 的温度是 34.3 C
bj 的温度是 26.7 C
sh 的温度是 32.5 C
hk 的温度是 30.5 C
```

上面输出结果是无序的，怎么实现有序输出？

```
>>> for city in sorted(temps):
...     print('%s 的温度是 %g C' % (city, temps[city]))
...
bj 的温度是 26.7 C
hk 的温度是 30.5 C
nb 的温度是 34.3 C
sh 的温度是 32.5 C
```

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## 查找键、删除元素

测试某个键是否在词典中

```
>>> if 'nb' in temps:
...     print('nb:', temps['nb'])
... else:
...     print('没有 nb 的温度')
...
nb: 34.3
>>> 'bj' in temps
True
```

删除某个元素

```
>>> temps
{'nb': 34.3, 'bj': 26.7, 'sh': 32.5, 'hk': 30.5}
>>> del temps['sh']
>>> temps
{'nb': 34.3, 'bj': 26.7, 'hk': 30.5}
```

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迭代器

```
>>> temps.keys()
dict_keys(['nb', 'bj', 'hk'])
>>> temps.values()
dict_values([34.3, 26.7, 30.5])
>>> for city in temps.keys():
...     print(city, temps[city])
...
nb 34.3
bj 26.7
hk 30.5
```

迭代器可以转成列表

```
>>> list(temps.keys())    >>> list(temps.values())
['nb', 'bj', 'hk']      [34.3, 26.7, 30.5]
```

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字典的复制

```
>>> t1 = temps
>>> t1['nb'] = 35
>>> temps
{'nb': 35, 'bj': 26.7, 'hk': 30.5}
>>> t2 = temps.copy()
>>> t2['nb'] = 10
>>> temps
{'nb': 35, 'bj': 26.7, 'hk': 30.5}
```

复习：列表也有类似的性质和操作

```
>>> L = [1, 2, 3]          >>> L = [1, 2, 3]
>>> M = L                  >>> M = L[:] # = L.copy()
>>> M[1] = 0               >>> M[2] = 0
>>> L                      >>> L
[1, 0, 3]                  [1, 2, 3]
```

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任意常量对象都可能作为字典的键

```
>>> a = {1: 65, 2: 67, 3: 89}    # 整数
>>> a
{1: 65, 2: 67, 3: 89}
>>> a = {1: 65, 2.3: 67, 3: 89}  # 整数, 浮点数
>>> a
{1: 65, 2.3: 67, 3: 89}
>>> a = {(0,1): 45, (2,3): 67}   # 元组
>>> a
{(0, 1): 45, (2, 3): 67}
>>> a = {[0,1]: 45, [2,3]: 67}   # 列表 (不是常量对象)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: unhashable type: 'list'
```

Notes

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例子：使用字典表示多项式

使用指数当键，系数当值

$p(x) = -1 + x^2 + 3x^7 \rightarrow p = \{0: -1, 2: 1, 7: 3\}$

定义计算多项式的函数  $p(x) = \sum c_i x^i$  eval\_poly\_dict.py

```
def poly_dict(poly, x):
    S = 0
    for power in poly:
        S += poly[power]*x**power
    # S = sum(poly[power]*x**power for power in poly)
    return S
```

```
p = {0: -1, 2: 1, 7: 3}
x = 2
print('p(%g) = %g' % (x, poly_dict(p,x)) )
```

```
>>>
p(2) = 387
```

Notes

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也可以使用列表表示多项式

用列表序号表示指数

$$p(x) = -1 + x^2 + 3x^7 \rightarrow p = [-1, 0, 1, 0, 0, 0, 0, 3]$$

定义计算多项式的函数  $p(x) = \sum c_i x^i$  eval\_poly\_list.py

```
def poly_list(poly, x):
    S = 0
    for power in range(len(poly)):
        S += poly[power]*x**power
    # S = sum(poly[i]*x**i for i in range(len(poly)))
    return S

p = [-1, 0, 1, 0, 0, 0, 0, 3]
x = 2
print('p(%g) = %g' % (x, poly_list(p,x)) )
```

>>> p(2) = 387

Notes

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哪一种表示方法好？

字典更短：字典只需要存储非 0 项，如对于多项式  $1 - x^{100}$

- 字典: `p = {0: 1, 100: -1}` # 长度 `len(p) = 2`
- 列表: `p = [1, 0, 0, 0, ..., -1]` # 长度 `len(p) = 101`

字典可以表示指数为负的情况，如  $x^{-3} + 2x^4$

```
p = {-3:1, 4:2}
x = 4
print('p(%g) = %g' % (x, poly_dict(p,x)) )
```

>>> p(4) = 512.016

字典可表示指数为非整的情况，如  $x^{-1/2} + 2x^\pi$

```
from math import pi
p = {-1/2: 1, pi: 2}
x = 4
print('p(%g) = %g' % (x, poly_dict(p,x)) )
```

>>> p(4) = 156.26

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课堂练习

1 计算多项式导数 文件名: poly\_diff.py

多项式的求导公式:

$$\frac{d}{dx} \sum_{j=0}^n c_j x^j = \sum_{j=1}^n j \cdot c_j x^{j-1}$$

在 python 中，多项式可以用一个字典来表示。请编写函数 diff 来计算这样一个多项式的导数，例如：

```
>>> p = {0: -3, 3: 2, 5: -1} # -3 + 2*x**3 - x**5
>>> diff(p) # 6*x**2 - 5*x**4
{2: 6, 4: -5}
```

提示: `dp[j-1] = j*p[j]`

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例子：读取文件数据到字典中

read\_temps\_dict.py

```
infile = open('cities_temp.txt', 'r')
temps = {}
for line in infile.readlines():
    city, temp = line.split(':')
    temps[city] = float(temp)
infile.close()
```

cities\_temp.txt

```
Oslo: 21.8
London: 18.1
Berlin: 19
Paris: 23
Rome: 26
Helsinki: 17.8
```

temps

```
{'Oslo': 21.8, 'London': 18.1, 'Berlin': 19.0, 'Paris': 23.0, 'Rome': 26.0, 'Helsinki': 17.8}
```

Notes

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例子：股价数据读入和可视化

```
stockprices_*.csv, * = {Apple, Google, Microsoft}
Date,Open,High,Low,Close,Volume,Adj Close
2014-02-03,37.74,37.99,35.69,37.42,42168900,37.42
2014-01-02,37.35,37.89,34.63,37.84,48732700,37.56
...
1986-03-13,25.50,29.75,25.50,27.50,155827200,0.07
```

写代码之前先设计算法

- 读数据：1. 跳过第一行；2. 一行行读取文件数据，使用逗号对每一行的文本进行切分，将第一个词存入一个日期列表中，将倒数第一个词（调整收盘价）存入价格列表中；3. 以公司为关键词将日期和价格列表存入字典；4. 编写函数读取一个公司的数据。
- 绘制图：将字符串形式的日期转换为年坐标（ $x$  轴），注意不同公司股票开始于不同年。

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字典

2024 年 9 月 1 日

17 / 37

Notes

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例子：股价数据读入和可视化

stockprices.py (接下页)

读数据函数

```
from datetime import datetime
def read_file(filename):
    infile = open(filename, 'r')
    infile.readline() # 跳过第一行
    dates = []; prices = []
    for line in infile:
        words = line.split(',')
        dates.append(words[0])
        prices.append(float(words[-1]))
    infile.close()
    dates.reverse(); prices.reverse()
    dates = [datetime.strptime(_date, '%Y-%m-%d').date()
              for _date in dates]
    prices = np.array(prices)
    return dates, prices
```

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例子：股价数据读入和可视化

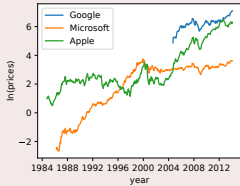
stockprices.py (接上页)

读入股价并可视化

```
import glob, numpy as np, matplotlib.pyplot as plt
dates = {}; prices = {}
filenames = glob.glob('stockprices_*.csv')
for filename in filenames:
    company = filename[12:-4]
    dates[company], prices[company] = read_file(filename)

for company in prices:
    x = dates[company]
    y = np.log(prices[company])
    plt.plot(x, y, label=company)

plt.xlabel('year')
plt.ylabel('ln(prices)')
plt.legend(); plt.show()
```



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课堂练习

2 嵌套字典

文件名: table2dict.py

表格文件 table.dat 的内容如下:

	A	B	C	D
1	11.7	0.035	2017	99.1
2	9.2	0.037	2019	101.2
3	12.2	no	no	105.2
4	10.1	0.031	no	102.1
5	9.1	0.033	2009	103.3
6	8.7	0.036	2015	101.9

建立字典结构（字典的字典），用 `data[p][i]` 存储第  $i$  (1, 2, ...) 行第  $p$  (A, B, ...) 列的数据。提示：

- 第一行：将第一行分成一个个词，将这些词作为键初始化字典，值为空。
- 剩余行：将每一行分成一个个词，第一个词作为键，后面的词，若不是 no，则作为值存入字典。

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<code>a = {}</code>	创建一个空字典
<code>a = {'k': [2,7], 's': 7}</code>	创建一个字典
<code>a = dict(k=[2,7], s=3)</code>	创建一个字典
<code>a.update(d)</code>	利用 b 中的键值来添加/更新 d
<code>a.update(k=v)</code>	添加/更新 a 中的键-值对
<code>a['hide'] = True</code>	将新的键-值对添加到 a
<code>a['k']</code>	获取键 'k' 对应的值
<code>for key in a:</code>	以未指定顺序对键进行循环
<code>for key in sorted(a):</code>	按字母顺序对键进行循环
<code>'k' in a</code>	'k' 是 a 中的键则返回 True
<code>del a['k']</code>	从 a 中删除键为 'k' 的键-值对
<code>list(a.keys())</code>	键列表
<code>list(a.values())</code>	值列表
<code>len(a)</code>	a 中键-值对的个数
<code>isinstance(a, dict)</code>	如果 a 是字典, 则返回 True
<code>get(a)</code>	返回键 a 的值, 若未找到该键返回 None
<code>get(a, b)</code>	返回键 a 的值, 若未找到该键返回 b

提要

1 字典

2 字符串

字符串

字符串处理

```
>>> s = 'This is a string'
>>> s.split()
['This', 'is', 'a', 'string']
>>> 'This' in s
True
>>> s.find('is')
2
>>> ', '.join(s.split())
'This, is, a, string'
```

字符串处理是文件内容操作的关键

- 文本在 Python 中的表示为字符串
- 文件内容的处理需要字符串处理的支持

子串操作

获取子串：类似于列表和数组

```
>>> s = 'NB: 18.4 C at 4 pm'
>>> s[1]
'B'
>>> s[-1]
'm'
>>> s[8:]
' C at 4 pm'
>>> s[8:12]
' C a'
>>> s[8:-1]
' C at 4 p'
```

查找子串：返回子串序号

```
>>> s.find('at')
11
>>> s.find('BJ')
-1
```

判断是否包含某个子串

```
>>> 'NB' in s
True
>>> 'BJ' in s
False
```

`s.replace(s1, s2)`: 将 `s` 中的 `s1` 替换成 `s2`

```
>>> s = 'NB: 18.4 C at 4 pm'
>>> s.replace(' ', '-')
'NB:-18.4-C-at-4-pm'
>>> s.replace('NB', 'BJ')
'BJ: 18.4 C at 4 pm'
```

将第一个冒号前的字符串替换成 'SH'

```
>>> s
'NB: 18.4 C at 4 pm'
>>> s.replace(s[:s.find(':')], 'SH') # s.find(':') = 2
'SH: 18.4 C at 4 pm'
>>> s.replace(s[:s.find(';')], 'SH') # s.find(';') = -1
'SHm'
```

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`s.split(sep)`: 将 `s` 用 `sep` 划分成子串列表, `sep` 缺省时使用空格

```
>>> s = 'NB: 18.4 C at 4 pm'
>>> s.split(':')
['NB', ' 18.4 C at 4 pm']
>>> s.split()
['NB:', '18.4', 'C', 'at', '4', 'pm']
>>> s.split(':')[1].split()[0] # 尝试理解一下这行程序
'18.4'
```

按行拆分: 多行文本行间由 `\n` (Linux) 或 `\r\n` (Windows) 隔开

```
>>> t = '1st line\n2nd line\n3rd line'
>>> print(t)
1st line
2nd line
3rd line
>>> t.split('\n')
['1st line', '2nd line', '3rd line']
>>> t.splitlines() # 跨平台
['1st line', '2nd line', '3rd line']
```

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字符串不能被改变

```
>>> s = 'NB: 18.4 C at 4 pm'
>>> s[4:8]
'18.4'
>>> s[4:8] = '20.5'
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: 'str' object does not support item assignment
```

所有对字符串的“修改”都是生成一个新串

```
>>> s = s[:4] + '20.5' + s[8:]
>>> s
'NB: 20.5 C at 4 pm'
```

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删除首尾空格

```
>>> s = ' NB: 18.4 C at 4 pm '
>>> s.strip()
'NB: 18.4 C at 4 pm'
```

删除首 (左) 空格

```
>>> s.lstrip()
'NB: 18.4 C at 4 pm '
```

删除尾 (右) 空格

```
>>> s.rstrip()
' NB: 18.4 C at 4 pm'
```

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## 其它常用字符串函数

### 判断对象是数字

```
>>> '315'.isdigit()
True
>>> '3.15'.isdigit()
False
>>> ' 315 '.isdigit()
False
```

### 转换大小写

```
>>> s = 'NB: 18.4 C at 4 pm'
>>> s.upper()
'NB: 18.4 C AT 4 PM'
>>> s.lower()
'nb: 18.4 c at 4 pm'
```

### 判断起始字符串

```
>>> s.startswith('NB')
True
>>> s.endswith('am')
False
```

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## 字符串连接

### 用分隔符连接字符串

```
>>> slist = ['NBU', 'PKU', 'THU']
>>> ','.join(slist)
'NBU,PKU,THU'
>>> ','.join(slist).split(',') # 两个互逆的操作
['NBU', 'PKU', 'THU']
```

### 例子：去掉一行中的前两个单词

```
>>> line = 'This is a line of words separated by space'
>>> words = line.split()
>>> line2 = ' '.join(words[2:])
>>> line2
'a line of words separated by space'
```

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## 例子：从文件读取数字对 (x, y)

### pairs.dat

```
(1.3,0) (-1,2) (3,-1.5) (5,-7) (3.4,2)
(0,1) (1,0) (1,1) (8,2.9) (6.2,7)
(0,-0.01) (10.5,-1) (2.5,-2.5) (9,3.2) (3,7.2)
```

### 算法

- 一行行读取文件内容
- 对每一行，分出一个个词
- 对每个词，去掉前后括号，然后用逗号分出两个数值

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## 例子：从文件读取数字对 (x, y)

### read\_pairs.py

```
with open('pairs.dat', 'r') as infile:
    lines = infile.readlines()

pairs = []
for line in lines:
    words = line.split()
    for word in words:
        word = word[1:-1] # 去掉括号
        n1, n2 = word.split(',')
        n1, n2 = float(n1), float(n2)
        pair = (n1, n2)
        pairs.append(pair)

import pprint
pprint.pprint(pairs)
```

### IDLE Shell

```
[(1.3, 0.0),
 (-1.0, 2.0),
 (3.0, -1.5),
 (5.0, -7.0),
 (3.4, 2.0),
 (0.0, 1.0),
 (1.0, 0.0),
 (1.0, 1.0),
 (8.0, 2.9),
 (6.2, 7.0),
 (0.0, -0.01),
 (10.5, -1.0),
 (2.5, -2.5),
 (9.0, 3.2),
 (3.0, 7.2)]
```

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例子：从文件读取数字对 (x, y) - 使用格式转换实现

```
>>> s = '(1,3,0) (-1,2) (3.4,2)\n(0,1) (3,-1.5) (5,-7)'\n>>> s = '[' + s.replace(')', ',') + ']'\n>>> s\n'[(1,3,0), (-1,2), (3.4,2),\n(0,1), (3,-1.5), (5,-7),]'\n>>> eval(s)\n[(1.3, 0), (-1, 2), (3.4, 2), (0, 1), (3, -1.5), (5, -7)]
```

```
read_pairs2.py
```

```
with open('pairs.dat', 'r') as infile:
    text = infile.read()

text = '[' + text.replace(')', '),') + ']'
```

```
text = '[' + text.replace(')', '),') + ']'
pairs = eval(text)
```

## 课堂练习

3 代码转换 文件名: python2to3.py

文件名: python2to3.py

Python3 和 Python2, 并不完全兼容, 一些语法上有差异。例如, 从 Python2 变为 Python3, 以下两种情况的代码就需要做相应的更改:

- 将字典 d 键转列表: `d.keys()` → `list(d.keys())`

- 将字典 d 键转列表: `d.keys() → list(d.keys())`
- 使用 `print` 输出 x: `print x → print(x)`

请编写程序读入以下 Python2 版本的代码 `python2.py`，并通过字符串处理，将其转化为 Python3 版本的代码，并用 `exec` 函数执行并输出运行结果。

```
postcode = {'NEU': 315211, 'THU': 100084, 'ZJU': 310053}
U = postcode.keys() # -> U = list(postcode.key())
print postcode      # -> print(postcode)
print 'U =', U      # -> print('U =', U)
```

### 例子：从网上获取数据并读入

<https://www.metoffice.gov.uk/.../oxforddata.txt>

Oxford  
Location: 450900E 207200N, Lat 51.761 Lon -1.262, 63 metres amsl  
Estimated data is marked with a \* after the value.  
Missing data (more than 2 days missing in month) is marked by ---.  
Sunshine data taken from an automatic Kipp & Zonen sensor marked ...

yyyy	mm	tmax	tmin	af	rain	sun
		degC	degC	days	mm	hours

yyyy	mm	tmax	tmin	af	rain	sun
		degC	degC	days	mm	hours
1853	1	8.4	2.7	4	62.8	---
1853	2	3.2	-1.8	19	29.3	---

```
...
1853 12 3.7 -1.3 19 10.7 ---
```

...						
2023	1	8.5	2.6	8	57.2	91.6

2023	2	10.4	3.0	9	7.6	91.2
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2023	12	10.2	5.2	5	117.2	21.9*
2024	1	9.9	9.9	9	73.9	73.7

2024	1	8.0	2.6	6	76.3	79.7	Provisional
2024	2	11.6*	5.4	2	111.9	57.3*	Provisional

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### 例子：从网上获取数据并读入

算法

- 从文件头读取城市和位置信息，然后跳过接下来的 5 行
- 读取每一行信息存入字典，注意处理 '\*' 和 'Provisional'

historic\_weather.py (接下页)

```
import urllib.request
url = 'https://www.metoffice.gov.uk/pub/data/weather/uk\
/climate/stationdata/oxforddata.txt'
local_file = 'Oxford.txt'
urllib.request.urlretrieve(url, filename=local_file)
infile = open(local_file, 'r')
data = {};
data['place'] = infile.readline().strip()
data['location'] = infile.readline().strip()
for i in range(5): infile.readline()
```

## Notes

[illegible]

## Notes

[illegible]

## Notes

[illegible]

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historic\_weather.py (接上页)

```
data['data'] = {}
for line in infile:
    columns = line.split()
    year, month = int(columns[0]), int(columns[1])
    if columns[-1] == 'Provisional': del columns[-1]
    for i in range(2, len(columns)):
        if columns[i] == '---':
            columns[i] = None
        elif columns[i][-1] == '*' or columns[i][-1] == '#':
            columns[i] = float(columns[i][: -1])
        else:
            columns[i] = float(columns[i])
    tmax, tmin, air_frost, rain, sun = columns[2:]
    if not year in data['data']: data['data'][year] = {}
    data['data'][year][month] = {'tmax': tmax,
                                  'tmin': tmin, 'air frost': air_frost, 'sun': sun}
infile.close()
```

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The End!