Math 5680: Mathematics of Machine Learning

Lab 2: Pandas (cont'd)

What is Pandas?

From https://pandas.pydata.org/pandas-docs/stable:

> Pandas is a Python package providing fast, flexible, and expressive data structures designed to make working with "relational" or "labeled" data both easy and intuitive. It aims to be the fundamental high-level building block for doing practical, real world data analysis in Python. Additionally, it has the broader goal of becoming the most powerful and flexible open source data analysis / manipulation tool available in any language. It is already well on its way toward this goal.
>
> Pandas is well suited for many different kinds of data:
>
> - Tabular data with heterogeneously-typed columns, as in an SQL table or Excel spreadsheet
> - Ordered and unordered (not necessarily fixed-frequency) time series data.
> - Arbitrary matrix data (homogeneously typed or heterogeneous) with row and column labels
> - Any other form of observational / statistical data sets. The data actually need not be labeled at all to be placed into a pandas data structure

Pandas is built with NumPy

NumPy provides multi-dimensional list-like data structures which are **typed** and much faster than Python lists. The interface to the pandas data structures is very similar to the one provided by NumPy. In many cases the methods provided have the same, or similar, names. For more detailed discussion of NumPy, please refre to the documentation.

5. Apply + Lambda

I want to briefly show you a decent idiom for doing more complicated work on a `Series` object.

This is a contrived example, but it shows the utility of `apply` + `lambda`. What if we wanted wanted to figure out if all letters A–Z are in the names of the states? First, we could create a `set` of characters in each state's name:

In [27]:
```python
# don't use the names of states an the index!
states = pd.read_csv("states.csv")

def set_of_chars(s):
    return set(list(s.lower()))

series_of_sets = states.State.apply(lambda s: set_of_chars(s))
series_of_sets
```

```
Out[27]:  0                                          {m, b, l, a}
          1                                          {k, l, s, a}
          2                                       {z, r, a, i, n, o}
          3                                        {k, s, r, a, n}
          4                                    {l, r, c, a, i, n, f, o}
          5                                      {d, l, r, c, a, o}
          6                                      {u, c, t, i, e, n, o}
          7                                      {d, l, r, w, a, e}
          8           {d, s, l, u, m, r, c,  , t, a, b, i, f, o}
          9                                    {d, l, r, a, i, f, o}
          10                                     {r, a, i, e, g, o}
          11                                         {h, i, w, a}
          12                                      {d, h, a, i, o}
          13                                      {l, s, i, n, o}
          14                                         {d, i, n, a}
          15                                         {a, i, o, w}
          16                                       {k, s, n, a}
          17                                    {k, u, c, t, e, y, n}
          18                                    {s, l, u, a, i, n, o}
          19                                       {m, a, i, e, n}
          20                                    {d, m, l, r, a, y, n}
          21                                    {h, m, s, u, c, a, t, e}
          22                                    {h, m, c, a, i, n, g}
          23                                    {s, m, t, a, i, e, n, o}
          24                                         {p, m, s, i}
          25                                    {m, u, s, r, i, o}
          26                                       {m, a, t, n, o}
          27                                    {k, s, r, a, b, e, n}
          28                                       {d, a, v, e, n}
          29           {h, m, s, r,  , w, a, i, e, n, p}
          30                                    {s, r,  , w, j, e, y, n}
          31                                    {x, m, c,  , w, i, e, n, o}
          32                                    {k, r,  , w, e, y, n, o}
          33                                    {h, l, r, c,  , t, a, i, n, o}
          34                                    {k, d, h, r,  , t, a, n, o}
          35                                                {h, o, i}
          36                                    {k, l, h, m, a, o}
          37                                       {r, g, e, n, o}
          38                                    {s, l, a, v, i, e, y, n, p}
          39                                    {d, h, s, l, r,  , a, i, e, n, o}
          40           {h, s, u, l, r, c,  , t, a, i, n, o}
          41                                    {k, d, h, s, u,  , t, a, o}
          42                                       {s, n, e, t}
          43                                       {x, s, a, t, e}
          44                                       {a, h, u, t}
          45                                    {m, r, t, v, e, n, o}
          46                                       {r, g, v, a, i, n}
          47                                    {h, s, a, w, g, t, i, n, o}
          48           {s, r,  , t, w, v, a, i, n, e, g}
          49                                    {s, c, w, i, n, o}
          50                                    {m, w, g, i, y, n, o}
          51                                    {u, r, c,  , t, i, e, o, p}
          Name: State, dtype: object
```

Reminder: Lambdas

Reminder, a *lambda* constructs an ephemeral unnamed function. This is opposed to the named function `set_of_chars` above. The point is the `apply` method takes a function. We could have done the following:

```
series_of_sets = states.State.apply(lambda s:
set(list(s.lower())))
```

Or, simply:

```
series_of_sets = states.State.apply(set_of_chars)
```

Let's Go Back to the Problem

Now we have a `Series` of `set`s each containing the unique characters contained in each state's name. Next, we need to combine all of these sets into a single one!

- First, an example of combining sets

In [28]:
```
a = {1, 2, 3}
b = {2, 4}
a.union(b)
```

Out[28]: `{1, 2, 3, 4}`

Now, we are going to **reduce** the `Series` of `set`s by taking the union of each entry. If done step by step:

```
_tmp = <zeroth_set>.union(<first_set>)
_tmp = _tmp.union(<second_set>)
_tmp = _tmp.union(<third_set>)
...
_tmp = _tmp.union(<final_set>)
```

Imagine if we had a million rows! Luckily, Python includes functions for this! It is called `reduce` and comes from the `functools` package. All we need to do is provide a function which combines two elements and it will recursively apply the function until there is only one value. Try the cell below:

In [29]:
```python
from functools import reduce
chars_used_in_states_name = reduce(lambda x, y: x.union(y), series_of_sets)
chars_used_in_states_name
```

Out[29]:
```
{' ',
 'a',
 'b',
 'c',
 'd',
 'e',
 'f',
 'g',
 'h',
 'i',
 'j',
 'k',
 'l',
 'm',
 'n',
 'o',
 'p',
 'r',
 's',
 't',
 'u',
 'v',
 'w',
 'x',
 'y',
 'z'}
```

Lastly, we need to remove any non-alphanumeric characters

- `ascii_lowercase` from `string` is simply a string of all of the characters
   - We can test if something is part of this set by using the `in` function, try the cell below:

In [30]:
```python
from string import ascii_lowercase
print(" " in ascii_lowercase) # Should print `False`
print("a" in ascii_lowercase) # Should print `True`
```

```
False
True
```

- We can use a set comprehension to filter the non-ascii characters

In [31]:
```python
chars_used_in_states_name = {x for x in chars_used_in_states_name if x in asc
chars_used_in_states_name
```

Out[31]:
```
{'a',
 'b',
 'c',
 'd',
 'e',
 'f',
 'g',
 'h',
 'i',
 'j',
 'k',
 'l',
 'm',
 'n',
 'o',
 'p',
 'r',
 's',
 't',
 'u',
 'v',
 'w',
 'x',
 'y',
 'z'}
```

- Now we can answer our question!

Are all of the characters used in the states names?

In [32]:
```
alphabet_set = set(list(ascii_lowercase))
alphabet_set.difference(chars_used_in_states_name)
```

Out[32]: `{'q'}`

The concepts of reductions and anonymous functions can be very useful when doing data analysis!

6. Built-in Methods and Axis

There are many built-in methods in Pandas, for example `.mean()` . By default, these methods operate on the columns with an argument called the `axis` with a default value of `0` . You can generate row based means with `axis=1` .

Task 9:

1. Run the definitions cell
2. Generate the column and row means for `states` using the axis argument
3. Generate the DataFrame mean, i.e. a single value, for `states`

```
In [ ]:
# definitions
states = pd.read_csv("states.csv", index_col=0)
states.head()
```

7. Writing Files

CSV files are a standard way to share data, one can write a `DataFrame` to a CSV file using the syntax:

```
<df>.to_csv(<filename.csv>)
```

Notes:

- The seperator, by default, is a comma. Try `sep="|"` argument, use a '.bsv' ending
- To not include the index, use `index=None`
- To not include a header, use `header=None`

Task 10:

1. Run the definitions cell
2. Write the `states` DataFrame to a file called "intro.bsv"

```
In [ ]:
# definitions
states = pd.read_csv("states.csv", index_col=0)
```

8. Combining DataFrames

8.1. Merge

A `merge` operation takes two dataframes and tries to combine them side by side. Let's start with a basic example.

In [34]:
```python
left = pd.DataFrame({"id": [1, 2, 3], "names": ["Ethan", "Henry", "Mason"]})
left
```

Out[34]:

	id	names
0	1	Ethan
1	2	Henry
2	3	Mason

In [35]:
```python
right = pd.DataFrame({"id": [1, 2, 3], "names": ["Mark", "Luke", "Peter"]})
right
```

Out[35]:

	id	names
0	1	Mark
1	2	Luke
2	3	Peter

In [36]:
```python
pd.merge(left, right, on="id")
```

Out[36]:

	id	names_x	names_y
0	1	Ethan	Mark
1	2	Henry	Luke
2	3	Mason	Peter

The keyword `on` takes a column from both dataframes and creates a new `DataFrame` sharing that column. By default it will only merge columns where values are shared between the `DataFrame`s, i.e. an *inner join*. Example:

In [37]:
```python
left = pd.DataFrame({"id": [1, 3], "names": ["Ethan", "Mason"]})
right = pd.DataFrame({"id": [1, 2], "names": ["Mark", "Luke"]})
pd.merge(left, right, on="id")
```

Out[37]:

	id	names_x	names_y
0	1	Ethan	Mark

There are a few different choices for *how* you can join two `DataFrame`s

- Using the keys from the `left` `DataFrame`:

In [38]:
```python
pd.merge(left, right, on="id", how="left")
```

Out[38]:

	id	names_x	names_y
0	1	Ethan	Mark
1	3	Mason	NaN

- Using the keys from the `right` `DataFrame`:

In [39]:
```python
pd.merge(left, right, on="id", how="right")
```

Out[39]:

	id	names_x	names_y
0	1	Ethan	Mark
1	2	NaN	Luke

- Use all of the keys, an `outer` join:

In [40]:
```python
pd.merge(left, right, on="id", how="outer")
```

Out[40]:

	id	names_x	names_y
0	1	Ethan	Mark
1	3	Mason	NaN
2	2	NaN	Luke

8.2. Concatenate

`concat` is used to stack `DataFrame`s on top of one-another. It takes a list of `DataFrame`s. Let's look at a simple example:

In [41]:
```python
top    = pd.DataFrame({"letters": ["a", "b", "c"], "numbers": [1, 2, 3]})
bottom = pd.DataFrame({"letters": ["g", "h", "i"], "numbers": [7, 8, 9]})
pd.concat([top, bottom])
```

Out[41]:

	letters	numbers
0	a	1
1	b	2
2	c	3
0	g	7
1	h	8
2	i	9

Task 11:

1. Run the definitions cell below
2. Try to merge `top` and `middle` using an `outer` join on the `"numbers"` column
3. Guess what will happen if you do an `inner` join? Test your hypothesis
4. Try to concatenate `top`, `middle`, and `bottom`

In [42]:
```python
# definitions
top    = pd.DataFrame({"letters": ["a", "b", "c"], "numbers": [1, 2, 3]})
middle = pd.DataFrame({"letters": ["d", "e", "f"], "numbers": [4, 5, 6]})
bottom = pd.DataFrame({"letters": ["g", "h", "i"], "numbers": [7, 8, 9]})
```

In [43]:
```python
pd.merge(top, middle, on="numbers", how="outer")
```

Out[43]:

	letters_x	numbers	letters_y
0	a	1	NaN
1	b	2	NaN
2	c	3	NaN
3	NaN	4	d
4	NaN	5	e
5	NaN	6	f

In [44]:
```python
pd.merge(top, middle, on="numbers")
```

Out[44]:

letters_x	numbers	letters_y

In [45]:
```python
pd.merge(pd.merge(top, middle, on="numbers", how="outer"), bottom, on="number
```

Out[45]:

	letters_x	numbers	letters_y	letters
0	a	1	NaN	NaN
1	b	2	NaN	NaN
2	c	3	NaN	NaN
3	NaN	4	d	NaN
4	NaN	5	e	NaN
5	NaN	6	f	NaN
6	NaN	7	NaN	g
7	NaN	8	NaN	h
8	NaN	9	NaN	i

9. Reshaping DataFrames

9.1. Grouping Data

Let's work with some real data in this example. First, we should get an idea of the shape of the data:

```
In [46]:    data311 = pd.read_csv("311.csv")
            data311.head()
```

Out[46]:

	_id	REQUEST_ID	CREATED_ON	REQUEST_TYPE	REQUEST_ORIGIN	STATUS	DEPARTMEN
0	70915	161823.0	2017-06-14T10:03:00	Rodent control	Call Center	1	Animal Care Contr
1	48238	178453.0	2017-08-11T08:03:00	Illegal Parking	Call Center	1	Police - Zone 1-
2	38897	178457.0	2017-08-11T08:37:00	Potholes	Call Center	1	DPW - Stre Maintenanc
3	57156	178460.0	2017-08-11T08:45:00	Dead tree (Public property)	Call Center	1	DPW Forest Divisio
4	53592	178463.0	2017-08-11T08:49:00	Weeds/Debris	Call Center	1	Permit Licenses ar Inspectior

This data was collected by the city of Pittsburgh from 311 calls. We are going to use the `groupby` functionality to extract some information from this data.

Let's extract some data for each neighborhood. First we will create a `groupby` object for the column `"NEIGHBORHOOD"`.

```
In [47]:    neighborhood = data311.groupby(by="NEIGHBORHOOD")
```

```
In [48]:    # Number of groupds
            neighborhood.ngroups
```

Out[48]:   91

```
In [49]:    # Data (row number) from each group
            neighborhood.groups
```

Out[49]:   {'Allegheny Center': [393, 697, 1181, 1649, 1846, 2126, 2376, 2682, 2843, 4190
            , 4522, 4539, 4673, 4678, 4909, 5209, 5960, 5998, 6355, 6761, 7111, 7209, 7514
            , 7573, 7891, 7925, 7932, 7956, 8062, 8229, 8360, 10065, 11391, 11392, 11393,
            11506, 11570, 11766, 12276, 13135, 13837, 14286, 14360, 14410, 14712, 15035, 1
            6937, 17597, 17599, 17600, 17603, 17609, 18237, 18352, 18493, 18598, 18829, 18
            898, 19793, 20146, 20171, 20210, 20211, 20229, 20584, 20586, 20973, 20977, 210
            28, 21197, 21286, 21303, 21322, 21420, 21510, 21720, 21936, 22378, 22639, 2327
            3, 23872, 24499, 24915, 25397, 26008, 26692, 26837, 26886, 26971, 26983, 27073
            , 27260, 27637, 27851, 28334, 29010, 29784, 29969, 30256, 30261, ...], 'Allegh
```

eny West': [781, 1493, 1494, 1667, 2256, 2278, 3484, 4541, 4769, 5475, 5918, 6
185, 6305, 7018, 7471, 7874, 9177, 9212, 10317, 10676, 10720, 11339, 12799, 13
589, 13653, 14816, 15120, 15644, 15645, 15646, 15914, 16661, 18318, 18622, 186
93, 18696, 18944, 18994, 19223, 20797, 20890, 21149, 21511, 21808, 21920, 2334
9, 23368, 24043, 24849, 25039, 25167, 25267, 26064, 26065, 26295, 26670, 27707
, 30253, 30264, 30675, 31728, 31764, 31801, 31870, 32010, 32983, 35179, 36281,
36367, 36522, 37004, 37431, 39337, 39411, 39697, 39740, 40540, 42152, 42530, 4
4345, 44604, 45564, 46136, 46819, 47582, 47604, 47947, 48906, 49405, 49748, 51
193, 51501, 51662, 51924, 52140, 52400, 53911, 54205, 55284, 56517, ...], 'All
entown': [5, 28, 370, 449, 478, 479, 487, 587, 588, 844, 1096, 1394, 1433, 148
8, 1566, 1644, 1695, 1744, 1847, 1938, 2503, 2523, 2524, 2543, 2604, 2636, 271
3, 2714, 2895, 2897, 2949, 3248, 3294, 3295, 3296, 3350, 3353, 3477, 3545, 361
8, 3660, 3682, 3874, 4075, 4078, 4080, 4096, 4120, 4135, 4159, 4160, 4161, 416
8, 4181, 4239, 4249, 4250, 4251, 4282, 4508, 4632, 4757, 4870, 4988, 5192, 524
4, 5267, 5288, 5361, 5367, 5432, 5488, 5503, 5560, 5574, 5604, 5624, 5704, 591
6, 5989, 6247, 6452, 6453, 6562, 6569, 6604, 6749, 6949, 6998, 7435, 7462, 750
4, 7730, 7791, 7818, 7836, 7949, 7950, 7951, 7993, ...], 'Arlington': [346, 40
9, 547, 550, 641, 858, 884, 919, 1141, 1175, 1335, 1399, 1678, 1691, 1717, 174
6, 2070, 2089, 2231, 2363, 2364, 2532, 2533, 2728, 2729, 2730, 2735, 2736, 295
0, 2951, 3101, 3162, 3210, 3277, 3287, 3318, 3328, 3435, 3479, 3520, 4069, 410
8, 4232, 4446, 4452, 4470, 4492, 4865, 4913, 4936, 5220, 5314, 5331, 5346, 537
8, 5384, 5453, 5476, 5498, 5596, 5643, 5698, 5700, 5711, 5770, 5779, 5872, 600
6, 6040, 6053, 6093, 6098, 6132, 6282, 6476, 6789, 6974, 7316, 7334, 7353, 740
0, 7494, 7503, 7542, 7618, 7626, 7641, 7650, 7678, 7742, 7785, 7794, 8209, 823
5, 8328, 8347, 8440, 8584, 8592, 8946, ...], 'Arlington Heights': [60, 17305,
17819, 19339, 23024, 23033, 23933, 24300, 28710, 55484, 60207, 61936, 62005, 7
4046, 80972, 82945, 88611, 89186, 91327, 102216, 105649, 116953, 120139, 12084
2, 122052, 136075, 137171, 139416, 142130, 143064, 143119, 146885, 149166, 152
250, 159533, 162832, 169755, 171225, 172351, 172417, 172491, 183907, 194507, 2
00797, 205628, 215862, 219430, 225334, 239916, 245853, 246408, 253399, 261717,
262076, 262169, 272936, 274459, 277984, 293577, 295344, 295457, 297987, 300657
, 303023, 303543, 318610, 331183, 334909, 345249, 352770, 355605, 359610, 3614
47, 361508, 364700, 365778, 370849, 377095, 378997, 382310, 399546, 402208, 41
6205, 417703, 420563, 420588, 425309, 427842, 443452, 445792, 482016, 489930,
491089, 492783, 497253, 499480, 500146, 500946, 501760, 506610, ...], 'Banksvi
lle': [3, 162, 192, 759, 899, 1520, 1522, 1608, 1884, 2045, 2046, 2249, 2625,
2850, 2859, 2953, 3253, 3551, 3739, 3835, 4091, 4208, 4382, 4710, 4796, 5173,
5174, 5272, 5441, 5953, 6085, 6333, 6335, 6345, 6495, 6542, 6620, 6696, 6989,
7391, 7449, 7834, 7845, 8330, 8398, 8897, 9017, 9081, 9154, 9229, 9391, 9516,
9746, 9748, 10061, 10068, 10124, 10149, 10285, 10304, 10322, 10395, 10785, 110
95, 11223, 11500, 11609, 11740, 12361, 12506, 12564, 12578, 13073, 13102, 1320
4, 13452, 13585, 13744, 13756, 13907, 14049, 14181, 14369, 14473, 14492, 14606
, 14628, 15406, 15411, 15446, 15543, 15702, 15800, 15878, 15949, 15950, 15978,
16140, 16413, 16454, ...], 'Bedford Dwellings': [265, 439, 474, 859, 1004, 100
5, 1018, 1020, 1500, 3715, 4450, 4451, 4465, 4466, 4599, 4783, 5458, 5701, 627
2, 7233, 7777, 8068, 8621, 9197, 9199, 9422, 12088, 12179, 12549, 13975, 14161
, 14746, 16948, 16975, 17046, 19496, 19637, 21002, 21284, 21357, 22470, 22485,
23937, 24811, 26092, 26657, 27100, 27540, 27916, 28015, 28041, 28442, 28691, 3
0118, 30790, 31704, 31725, 31826, 32238, 32243, 33105, 33224, 33225, 33437, 33
551, 33638, 33727, 33779, 33933, 33959, 34203, 34315, 34718, 35689, 35963, 366
18, 37054, 37056, 37097, 38593, 38680, 38681, 38682, 39059, 39727, 39729, 3973
0, 39731, 39732, 39733, 39736, 39779, 42564, 44111, 44317, 44322, 46349, 47626
, 48658, 49223, ...], 'Beechview': [38, 86, 110, 111, 128, 131, 154, 175, 482,

578, 627, 648, 654, 876, 877, 917, 939, 956, 1038, 1044, 1065, 1066, 1072, 108
8, 1167, 1254, 1311, 1364, 1432, 1454, 1495, 1547, 1620, 1638, 1684, 1769, 182
3, 1861, 1868, 1874, 1911, 1988, 2054, 2074, 2217, 2324, 2325, 2326, 2366, 240
6, 2429, 2450, 2461, 2550, 2590, 2593, 2603, 2674, 2770, 2874, 2876, 2975, 306
1, 3315, 3332, 3389, 3398, 3510, 3514, 3522, 3567, 3593, 3617, 3654, 3670, 370
5, 3766, 3831, 3898, 3945, 4038, 4066, 4112, 4142, 4207, 4255, 4365, 4514, 452
5, 4526, 4554, 4665, 4677, 4709, 4871, 4874, 4914, 4933, 4966, 4968, ...], 'Be
ltzhoover': [2, 8, 11, 12, 120, 238, 456, 777, 1360, 1537, 1766, 1775, 1778, 2
018, 2129, 2160, 2426, 2428, 2492, 2493, 2506, 2715, 3011, 3069, 3280, 3506, 3
774, 3915, 4322, 4329, 4340, 4563, 4582, 4639, 4643, 4775, 5057, 5097, 5198, 5
473, 5511, 5542, 5585, 6060, 6274, 6606, 6834, 6907, 7076, 7102, 7146, 7314, 7
714, 7774, 7787, 7898, 7977, 8061, 8197, 8215, 8230, 8799, 9010, 9058, 9106, 9
241, 9242, 9282, 9283, 9284, 9285, 9286, 9287, 9288, 9293, 9299, 9300, 9303, 9
305, 9306, 9364, 9447, 9645, 9876, 10019, 10444, 10450, 10586, 10699, 10730, 1
1041, 11067, 11183, 11573, 11953, 11954, 12207, 12666, 12743, 12801, ...], 'Bl
oomfield': [31, 85, 117, 122, 135, 178, 234, 249, 267, 290, 293, 296, 297, 298
, 413, 529, 594, 595, 616, 636, 670, 705, 706, 712, 737, 755, 848, 863, 864, 8
74, 1036, 1138, 1224, 1248, 1305, 1345, 1361, 1464, 1502, 1546, 1745, 1857, 18
85, 1944, 1958, 2017, 2048, 2050, 2052, 2128, 2188, 2192, 2280, 2281, 2283, 23
80, 2415, 2420, 2434, 2435, 2449, 2470, 2498, 2744, 2810, 2912, 2913, 3026, 30
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1329, 51647, 51670, 52072, 52467, 54343, 54779, 55188, 56406, 58323, 59687, 60079, 61331, 61694, 62239, 62269, 64111, 64386, 64870, 64872, 64874, 65906, 66012, 66193, 66194, 67075, 70197, 71122, 72492, 74132, 74740, 75198, 75242, 76119, 76276, 77016, 77185, 77186, 77615, ...], 'South Side Flats': [59, 66, 73, 78, 89, 91, 94, 100, 130, 142, 190, 201, 269, 338, 354, 355, 379, 462, 471, 489, 533, 540, 558, 669, 680, 694, 702, 713, 775, 779, 803, 804, 806, 867, 961, 982, 1026, 1048, 1111, 1249, 1255, 1256, 1294, 1340, 1373, 1396, 1427, 1469, 1479, 1536, 1571, 1585, 1587, 1588, 1589, 1599, 1600, 1601, 1623, 1650, 1658, 1659, 1803, 1828, 1829, 1832, 1833, 1844, 1862, 1960, 1961, 1965, 1966, 1971, 1973, 1974, 2032, 2062, 2119, 2125, 2135, 2140, 2173, 2180, 2182, 2183, 2215, 2227, 2265, 2288, 2293, 2304, 2310, 2365, 2374, 2379, 2401, 2425, 2430, 2441, ...], 'South Side Slopes': [7, 19, 36, 74, 90, 95, 160, 205, 321, 334, 340, 347, 348, 351, 369, 378, 380, 432, 434, 556, 579, 610, 662, 687, 690, 745, 815, 830, 856, 882, 887, 904, 935, 942, 950, 1103, 1110, 1143, 1161, 1190, 1203, 1204, 1206, 1208, 1319, 1323, 1343, 1389, 1397, 1406, 1461, 1492, 1516, 1532, 1558, 1613, 1721, 1781, 1787, 1789, 1827, 1891, 2035, 2077, 2121, 2247, 2273, 2319, 2341, 2352, 2377, 2389, 2392, 2393, 2403, 2404, 2409, 2422, 2439, 2440, 2453, 2458, 2516, 2547, 2561, 2578, 2589, 2601, 2662, 2732, 2772, 2826, 2840, 2882, 3054, 3077, 3080, 3122, 3216, 3263, ...], 'Spring Garden': [104, 1527, 1634, 1641, 1792, 1793, 2030, 2120, 2193, 2194, 2212, 2323, 3111, 3459, 3616, 3954, 4454, 5163, 5224, 5618, 5722, 6181, 6767, 6995, 7183, 7346, 7515, 7750, 7972, 8040, 8102, 8152, 9240, 9328, 9456, 9574, 9605, 9633, 9917, 10229, 10260, 10262, 11132, 11224, 11341, 11957, 12062, 12584, 12818, 12960, 14311, 14357, 14451, 14502, 14679, 14776, 15460, 15626, 15743, 16438, 16441, 16450, 16693, 16706, 16751, 16895, 17235, 18055, 18222, 18454, 18904, 18910, 19428, 20408, 20921, 20996, 21601, 21713, 21802, 22679, 22886, 23457, 23754, 23798, 24015, 24110, 24299, 24373, 24897, 24902, 24908, 25073, 25426, 25793, 26375, 26494, 26806, 26842, 26859, 27240, ...], 'Spring Hill-City View': [87, 402, 818, 922, 937, 1276, 1277, 1293, 1347, 1661, 2031, 2058, 2274, 2318, 2477, 2534, 2723, 3744, 3772, 3896, 4184, 4304, 4393, 4668, 4824, 5001, 5245, 5334, 5375, 5637, 5680, 5897, 5901, 6056, 6383, 6426, 6428, 6547, 6688, 6709, 6716, 6718, 6928, 7202, 7422, 7465, 7601, 8204, 8411, 8644, 8672, 8947, 9172, 9554, 9622, 9673, 9693, 9890, 9991, 10015, 10140, 10423, 10550, 10853, 10860, 10899, 11099, 11316, 11351, 11387, 11450, 11677, 11709, 11784, 11986, 12407, 12570, 12587, 12792, 13202, 13372, 13402, 13403, 13408, 13455, 13928, 14188, 14189, 14211, 14300, 14411, 14887, 14906, 15028, 15033, 15037, 15045, 15051, 15060, 15077, ...], 'Squirrel Hill North': [34, 92, 159, 168, 239, 270, 291, 428, 480, 514, 584, 599, 622, 632, 660, 665, 1068, 1077, 1082, 1129, 1318, 1351, 1388, 1565, 1617, 1637, 1750, 1812, 1848, 1889, 2149, 2195, 2229, 2246, 2330, 2331, 2348, 2617, 2618, 2628, 2802, 2824, 2845, 3073, 3095, 3108, 3177, 3238, 3252, 3466, 3565, 3724, 3737, 3855, 3887, 4017, 4065, 4248, 4496, 4513, 4640, 4667, 4713, 4725, 4787, 4828, 4905, 4995, 5156, 5183, 5199, 5281, 5301, 5390, 5422, 5451, 5538, 5543, 5731, 5751, 5752, 5785, 5786, 5788, 5836, 5949, 5959, 5980, 6062, 6069, 6262, 6311, 6431, 6458, 6488, 6589, 6632, 6634, 6722, 6744, ...], 'Squirrel Hill South': [1, 45, 49, 61, 214, 232, 283, 411, 437, 464, 553, 607, 647, 657, 765, 846, 890, 913, 938, 959, 993, 1039, 1053, 1094, 1105, 1118, 1121, 1146, 1169, 1173, 1179, 1253, 1263, 1365, 1498, 1523, 1579, 1612, 1676, 1714, 1723, 1754, 1786, 1970, 1992, 2020, 2063, 2093, 2191, 2196, 2200, 2201, 2204, 2254, 2255, 2307, 2339, 2497, 2505, 2515, 2519, 2528, 2530, 2554, 2582, 2632, 2640, 2681, 2749, 2750, 2751, 2875, 2887, 2906, 2925, 2979, 2990, 3007, 3110, 3178, 3218, 3223, 3225, 3237, 3347, 3431, 3458, 3505, 3558, 3579, 3585, 3599, 3695, 3709, 3713, 3861, 3872, 3907, 3909, 4016, ...], 'St. Clair': [557, 649, 3170, 3448, 5034, 5463, 5800, 6963, 7848, 8034, 10898, 11272, 11327, 12079, 12080, 12511, 12691, 13386

, 15817, 17744, 18208, 19401, 20790, 21702, 22771, 22912, 22986, 22987, 23681, 26999, 27979, 30292, 30399, 30932, 31340, 32159, 32161, 32370, 32974, 33802, 33979, 34433, 35592, 36323, 36984, 37235, 38113, 38122, 38176, 38856, 40964, 45038, 45971, 46035, 46200, 46446, 46566, 46839, 46844, 46911, 48645, 49547, 49818, 52880, 53206, 53681, 53694, 54178, 54971, 55898, 56288, 56332, 56345, 56911, 56912, 56913, 56932, 59680, 60361, 60453, 60626, 62755, 66621, 67443, 67782, 67993, 69864, 69973, 70424, 70770, 73526, 73529, 75659, 76263, 76330, 76701, 76702, 76801, 76888, 77256, ...], 'Stanton Heights': [62, 235, 241, 242, 244, 246, 247, 250, 251, 252, 256, 278, 404, 405, 455, 652, 762, 764, 796, 900, 1006, 1390, 1401, 1405, 1610, 1679, 1824, 1840, 1893, 2068, 2113, 2166, 2220, 2250, 2398, 2664, 2704, 2847, 3264, 3273, 3364, 3517, 3602, 3611, 3700, 3704, 3864, 3880, 3926, 4170, 4178, 4228, 4238, 4385, 4438, 4464, 4747, 4808, 5137, 5182, 5270, 5465, 5791, 5826, 5879, 5911, 5936, 6222, 6807, 6884, 7097, 7173, 7269, 7298, 7313, 7342, 7343, 7347, 7350, 7351, 7355, 7356, 7357, 7358, 7361, 7363, 7377, 7378, 7383, 7484, 7495, 7500, 7517, 7536, 7624, 7639, 7642, 7734, 7776, 7906, ...], 'Strip District': [613, 625, 634, 847, 948, 1085, 1127, 1225, 1264, 1379, 1381, 1664, 1873, 1910, 1943, 1951, 2069, 2844, 2892, 3005, 3006, 3013, 3105, 3130, 4294, 4504, 4651, 4701, 4705, 4970, 4985, 5036, 5098, 5134, 5175, 5682, 5917, 6107, 6177, 6280, 6472, 6578, 6741, 7030, 7144, 7222, 7453, 7680, 7946, 7947, 8080, 8134, 8136, 8332, 9150, 9462, 9544, 9589, 9667, 9779, 9803, 9918, 10113, 10159, 10254, 10257, 10259, 10877, 10971, 11025, 11026, 11042, 11069, 11131, 11188, 11295, 11727, 12137, 12439, 12600, 12618, 12812, 12888, 13140, 13178, 13179, 13180, 13461, 13499, 13809, 14343, 14349, 14544, 14582, 14586, 14760, 14767, 14859, 14919, 15039, ...], 'Summer Hill': [121, 194, 535, 2499, 3199, 3326, 3411, 3553, 3570, 5381, 5466, 5602, 5869, 5944, 6024, 6103, 6723, 6763, 6958, 7171, 7846, 8053, 8477, 8495, 8580, 8662, 9048, 9118, 9886, 10107, 10620, 11330, 11553, 12644, 12757, 12901, 13976, 14033, 14163, 14444, 14524, 14551, 14701, 15693, 15696, 15712, 15723, 15786, 15787, 15850, 16118, 16122, 16683, 18211, 18268, 18269, 18435, 18436, 18901, 19118, 19457, 19776, 20166, 20203, 20447, 21225, 21248, 23613, 23777, 25379, 25380, 25511, 25592, 25709, 26094, 26168, 26547, 27287, 27293, 28694, 28711, 28936, 29452, 29607, 29934, 29989, 30004, 30081, 30149, 30360, 30375, 30756, 32099, 32141, 32313, 32522, 32776, 32860, 32909, 33184, ...], 'Swisshelm Park': [491, 646, 2486, 2914, 3071, 4054, 4778, 6041, 6042, 6049, 6050, 6862, 6880, 6881, 6913, 6920, 7089, 8146, 8603, 8870, 9260, 9376, 9377, 11089, 12146, 12455, 12526, 13113, 14574, 15339, 15595, 15602, 16322, 16368, 16396, 16444, 16603, 16604, 16605, 17290, 17510, 17779, 17780, 18702, 19020, 19231, 19241, 19307, 19352, 19948, 21498, 21646, 22355, 22944, 22951, 24459, 24675, 25221, 25947, 27181, 27802, 27825, 29062, 29799, 30323, 30676, 31342, 31491, 31798, 32195, 32253, 32259, 33409, 33892, 34016, 34017, 34069, 34202, 35138, 35187, 35299, 35841, 36080, 36166, 36311, 36546, 37146, 37197, 37278, 37724, 38404, 38603, 39354, 40312, 40379, 40380, 40394, 40396, 40618, 40620, ...], 'Terrace Village': [800, 985, 1320, 1333, 1747, 3661, 3699, 4494, 5104, 5287, 5549, 5567, 5592, 5780, 6043, 6044, 6144, 6256, 6645, 6819, 7143, 8331, 8920, 9315, 9542, 9562, 10649, 11114, 11665, 11960, 13086, 14253, 15124, 15272, 15295, 15466, 15592, 15758, 16039, 17566, 17993, 18185, 19121, 19824, 19942, 20291, 20755, 20799, 20970, 21077, 21797, 21900, 22103, 22220, 22334, 22341, 22768, 22953, 24268, 25190, 25211, 25336, 25610, 25863, 26795, 27951, 30244, 31758, 31780, 32229, 32353, 32371, 32412, 32465, 32466, 32487, 32489, 32490, 32513, 32581, 32582, 32610, 33120, 33329, 33570, 33651, 33833, 34312, 34420, 34448, 34505, 34779, 34913, 34949, 35352, 35449, 35676, 35706, 35981, 35992, ...], 'Troy Hill': [84, 187, 254, 276, 287, 311, 314, 337, 465, 621, 722, 778, 821, 986, 1212, 1232, 1321, 1348, 1362, 1414, 1733, 1780, 1863, 2004, 2066, 2067, 2111, 2162, 2169, 2198, 2234, 2373, 2432, 2567, 2568,

2823, 3343, 3392, 3393, 3588, 3679, 3692, 3693, 3741, 3811, 3995, 4005, 4283, 4284, 4312, 4313, 4314, 4334, 4350, 4429, 4675, 4695, 4724, 4741, 4893, 4906, 4907, 4908, 4979, 5352, 5658, 5686, 5694, 5848, 5970, 6009, 6047, 6081, 6254, 6403, 6961, 7004, 7059, 7137, 7162, 7280, 7288, 7290, 7411, 7516, 7564, 7695, 8017, 8276, 8319, 8387, 8646, 8655, 8751, 8764, 8765, 8898, 8944, 8948, 8957, ...], 'Upper Hill': [389, 581, 600, 604, 617, 798, 799, 929, 973, 975, 1013, 1023, 1081, 1163, 1220, 1251, 1459, 1524, 1669, 1845, 2042, 2076, 2413, 2483, 2500, 2509, 2622, 2678, 2679, 2748, 3036, 3106, 3124, 3125, 3228, 3366, 3405, 3723, 3734, 3750, 3777, 4004, 4061, 4136, 4305, 4422, 4516, 4587, 4932, 5184, 5410, 5575, 5636, 5726, 5838, 5920, 5921, 6119, 6121, 6123, 6137, 6560, 6561, 6609, 6649, 6665, 6666, 7273, 7297, 7368, 7472, 7808, 7852, 7935, 7936, 7991, 8166, 8167, 8601, 8726, 8748, 8862, 8890, 8891, 8907, 8909, 8911, 8912, 8913, 8916, 9097, 9214, 9486, 9674, 9683, 9774, 9953, 10074, 10141, 10162, ...], 'Upper Lawrenceville': [240, 536, 537, 548, 602, 645, 717, 760, 878, 992, 1511, 1642, 1716, 1798, 1802, 1820, 1834, 1835, 1851, 1866, 1876, 1883, 2023, 2245, 2355, 2504, 3191, 3195, 3245, 3463, 3912, 3931, 4146, 4360, 4495, 4607, 4648, 4717, 4720, 4916, 5218, 5351, 5468, 5527, 5777, 5990, 6027, 6106, 6233, 6317, 6534, 6549, 6699, 6708, 6730, 6750, 6757, 6856, 7258, 7413, 7562, 7705, 7797, 7994, 8092, 8149, 8255, 8262, 8264, 8378, 8739, 8931, 9015, 9256, 9389, 9472, 9473, 9709, 9768, 9829, 10281, 10314, 10343, 10465, 10531, 10578, 10607, 10629, 10821, 10833, 10883, 11075, 11111, 11201, 11474, 11668, 11731, 11756, 11800, 11937, ...], 'West End': [47, 387, 580, 1196, 1755, 2001, 2407, 2754, 3176, 3317, 4107, 4664, 4679, 6715, 6951, 7746, 8119, 8402, 8794, 9664, 11574, 12463, 12668, 12773, 13188, 13206, 14025, 14241, 14388, 14497, 15165, 15542, 15557, 16449, 16496, 16518, 16749, 16878, 17039, 17120, 17370, 17513, 17904, 18152, 18241, 19005, 19814, 20097, 20240, 20533, 22740, 24311, 24777, 24790, 25289, 26360, 27164, 27368, 27412, 27570, 28089, 28512, 29265, 29317, 29648, 29708, 30152, 31268, 31943, 31945, 31957, 32533, 32790, 32818, 33652, 34289, 34690, 35211, 35251, 35406, 36851, 37406, 37958, 38127, 38129, 39265, 39340, 39385, 39663, 40269, 40589, 40590, 40601, 40602, 40609, 40723, 40867, 41225, 41843, 42047, ...], 'West Oakland': [40, 177, 183, 564, 809, 1336, 1339, 1548, 1550, 1627, 2109, 2334, 2718, 2899, 2908, 2909, 2910, 3179, 3180, 3196, 3403, 3487, 4094, 4095, 4164, 4589, 4616, 4782, 4954, 5080, 5103, 5320, 5461, 5500, 5568, 5744, 5763, 5986, 6046, 6138, 6161, 6728, 6729, 6912, 7276, 7439, 8004, 8019, 8032, 8273, 8393, 8439, 8456, 9434, 9490, 9669, 9672, 9988, 11004, 11179, 11397, 11441, 11656, 12021, 12053, 12072, 12651, 13079, 13170, 13263, 13331, 13385, 13841, 14147, 14213, 15130, 15132, 15187, 15224, 15228, 15253, 15496, 15793, 15908, 15969, 16020, 16023, 16282, 16452, 16590, 16636, 16647, 16743, 16821, 17007, 17236, 17259, 17614, 17684, 17717, ...], 'Westwood': [169, 218, 219, 233, 609, 734, 823, 879, 934, 954, 988, 1035, 1060, 1420, 1424, 1526, 1904, 1998, 2055, 2170, 2209, 2525, 2673, 2931, 2939, 2965, 3040, 3043, 3056, 3470, 3680, 3681, 4644, 4982, 5056, 5073, 5790, 6371, 6616, 6646, 6687, 7218, 7468, 7470, 7901, 8221, 8358, 8570, 8830, 9088, 9238, 9478, 9553, 9618, 10599, 10630, 10714, 11097, 11161, 11244, 11292, 11438, 11770, 12311, 12817, 12898, 12922, 13007, 13008, 13297, 13834, 13939, 14175, 14200, 14431, 14490, 14503, 14537, 14539, 14550, 14554, 14900, 14995, 15314, 15566, 15751, 16126, 16309, 17155, 17156, 17158, 17316, 17386, 17455, 17755, 17768, 17947, 17949, 18151, 18193, ...], 'Windgap': [790, 1457, 1597, 2177, 2272, 2460, 2619, 3227, 3523, 4214, 5071, 5437, 6413, 6802, 6955, 7136, 7330, 7380, 7442, 7582, 7783, 7894, 8178, 8385, 8859, 9031, 9959, 10284, 11981, 11983, 12211, 12633, 13850, 14323, 14573, 14821, 15042, 15059, 15175, 16053, 16138, 16469, 16472, 16519, 16857, 16887, 17047, 17071, 17693, 17694, 18217, 18689, 18919, 19305, 20040, 20186, 20311, 20885, 20936, 21228, 22102, 22993, 23153, 23361, 24250, 25142, 25153, 25183, 25726, 26052, 26558

```
, 26561, 26566, 26567, 26569, 26570, 26571, 26572, 26573, 26575, 26577, 26578,
26580, 27273, 27863, 28100, 28738, 28817, 28918, 29341, 29513, 29586, 30594, 3
0719, 31423, 31964, 32461, 32923, 33005, 33089, ...]}
```

In [50]:
```python
# Compute group size
neighborhood.size()
```

Out[50]:
```
NEIGHBORHOOD
Allegheny Center       2283
Allegheny West         1247
Allentown              7057
Arlington              5069
Arlington Heights       137
                       ...
Upper Lawrenceville    5732
West End               1554
West Oakland           3226
Westwood               3349
Windgap                2195
Length: 91, dtype: int64
```

In [51]:
```python
# Get data from one specific group
Arlington_Group = neighborhood.get_group('Arlington')
Arlington_Group.head()
```

Out[51]:

	_id	REQUEST_ID	CREATED_ON	REQUEST_TYPE	REQUEST_ORIGIN	STATUS	DEPARTM
346	4944	178681.0	2017-08-11T14:56:00	Patrol	Twitter	0	Police -
409	71295	160899.0	2017-06-09T17:11:00	Couch on Porch	Report2Gov iOS	1	Pe License Inspe
547	130500	92553.0	2016-08-01T09:26:00	Street Light - Repair	Call Center	1	Allegher E
550	71440	151450.0	2017-05-08T09:16:00	Overgrowth	Call Center	1	DPW - Mainter
641	71526	156483.0	2017-05-24T14:54:00	Weeds/Debris	Twitter	1	Pe License Inspe

- If we wanted to see all 311 calls for a particular neighborhood and request type we could simply make a groupby object for both columns!

In [52]:
```python
requests_by_neighborhood = data311.groupby(by=["NEIGHBORHOOD", "DEPARTMENT"])
requests_by_neighborhood.get_group(("Arlington", "311"))
```

Out[52]:

	_id	REQUEST_ID	CREATED_ON	REQUEST_TYPE	REQUEST_ORIGIN	STATUS	DEP/
4865	479509	466231.0	2020-09-14T09:23:00	Claim form (Law)	Call Center	1	
33678	603534	548568.0	2021-07-29T09:23:00	Referral	Call Center	1	
45779	160344	43934.0	2016-01-27T16:16:00	Schedule Request	Call Center	1	
79647	176393	5804.0	2015-05-20T14:52:00	DO NOT USE (Vacant and Open Building)	Call Center	1	
80290	188745	6403.0	2015-05-27T08:35:00	Schedule Request	Call Center	1	
...	...	...	...	...	...	...	
623214	733902	631207.0	2022-05-09T16:47:00	Claim form (Law)	Call Center	1	
628526	749149	644410.0	2022-06-13T09:57:00	City Cuts Concern	Call Center	1	
642641	782902	671692.0	2022-08-25T16:03:00	Vacant Lot	Website	1	
646946	784571	672899.0	2022-08-30T08:04:00	Police Department	Website	0	
649109	785190	673421.0	2022-08-31T10:14:00	Referral	Call Center	1	

92 rows × 18 columns

9.2. Dealing with Strings

If your working with string data there is a special method which allows you to apply normal string methods on the entire column.

This data set comes from the city of Pittsburgh. It is all of the trees that the city maintains. The dataset can be found at https://data.wprdc.org/dataset/city-trees (or on Canvas).

In [53]:
```
trees = pd.read_csv("trees.csv")
trees.head()
```

```
/Users/zhangyanz/opt/anaconda3/lib/python3.9/site-packages/IPython/core/intera
ctiveshell.py:3444: DtypeWarning: Columns (1) have mixed types.Specify dtype o
ption on import or set low_memory=False.
  exec(code_obj, self.user_global_ns, self.user_ns)
```

Out[53]:

	id	address_number	street	common_name	scientific_name	height	width
0	754166088	7428.0	MONTICELLO ST	Stump	Stump	0.0	0.0
1	1946899269	220.0	BALVER AVE	Linden: Littleleaf	Tilia cordata	0.0	0.0
2	1431517397	2822.0	SIDNEY ST	Maple: Red	Acer rubrum	22.0	6.0
3	994063598	608.0	SUISMON ST	Maple: Freeman	Acer x freemanii	25.0	10.0
4	1591838573	1135.0	N NEGLEY AVE	Maple: Norway	Acer platanoides	52.0	13.0

5 rows × 58 columns

First, a very simple example where we convert the `"street"` columns to lower case

In [54]:
```python
trees["street"].str.lower().head()
```

Out[54]:
```
0    monticello st
1        balver ave
2         sidney st
3        suismon st
4      n negley ave
Name: street, dtype: object
```

Strings have a `split` method. Given a string it will split the string up by that character into a list of strings. An example,

In [55]:
```python
"Maple: Red".split(":")
```

Out[55]:
```
['Maple', ' Red']
```