Lecture 6: Data Cleaning and Preparation

Handling Missing Data

```
In [10]: string_data = pd.Series(['aardvark', 'artichoke', np.nan, 'avocado'])

In [11]: string_data
Out[11]:
0     aardvark
1    artichoke
2          NaN
3      avocado
dtype: object

In [12]: string_data.isnull()
Out[12]:
0    False
1    False
2     True
3    False
dtype: bool
```

```
In [13]: string_data[0] = None

In [14]: string_data.isnull()
Out[14]:
0     True
1    False
2     True
3    False
dtype: bool
```

NA handling methods

Argument	Description
`dropna`	Filter axis labels based on whether values for each label have missing data, with varying thresholds for how much missing data to tolerate.
`fillna`	Fill in missing data with some value or using an interpolation method such as `'ffill'` or `'bfill'`.
`isnull`	Return boolean values indicating which values are missing/NA.
`notnull`	Negation of `isnull`.

Filtering Out Missing Data

```
In [15]: from numpy import nan as NA

In [16]: data = pd.Series([1, NA, 3.5, NA, 7])

In [17]: data.dropna()
Out[17]:
0    1.0
2    3.5
4    7.0
dtype: float64
```

```
In [18]: data[data.notnull()]
Out[18]:
0    1.0
2    3.5
4    7.0
dtype: float64
```

```
In [19]: data = pd.DataFrame([[1., 6.5, 3.], [1., NA, NA],
    ....:                     [NA, NA, NA], [NA, 6.5, 3.]])

In [20]: cleaned = data.dropna()

In [21]: data
Out[21]:
     0    1    2
0  1.0  6.5  3.0
1  1.0  NaN  NaN
2  NaN  NaN  NaN
3  NaN  6.5  3.0

In [22]: cleaned
Out[22]:
     0    1    2
0  1.0  6.5  3.0
```

```
In [23]: data.dropna(how='all')
Out[23]:
     0    1    2
0  1.0  6.5  3.0
1  1.0  NaN  NaN
3  NaN  6.5  3.0
```

```
In [24]: data[4] = NA

In [25]: data
Out[25]:
     0    1    2   4
0  1.0  6.5  3.0 NaN
1  1.0  NaN  NaN NaN
2  NaN  NaN  NaN NaN
3  NaN  6.5  3.0 NaN

In [26]: data.dropna(axis=1, how='all')
Out[26]:
     0    1    2
0  1.0  6.5  3.0
1  1.0  NaN  NaN
2  NaN  NaN  NaN
3  NaN  6.5  3.0
```

```
In [27]: df = pd.DataFrame(np.random.randn(7, 3))

In [28]: df.iloc[:4, 1] = NA

In [29]: df.iloc[:2, 2] = NA

In [30]: df
Out[30]:
          0         1         2
0 -0.204708       NaN       NaN
1 -0.555730       NaN       NaN
2  0.092908       NaN  0.769023
3  1.246435       NaN -1.296221
4  0.274992  0.228913  1.352917
5  0.886429 -2.001637 -0.371843
6  1.669025 -0.438570 -0.539741

In [31]: df.dropna()
Out[31]:
          0         1         2
4  0.274992  0.228913  1.352917
5  0.886429 -2.001637 -0.371843
6  1.669025 -0.438570 -0.539741

In [32]: df.dropna(thresh=2)
```

```
In [31]: df.dropna()
Out[31]:
          0         1         2
4  0.274992  0.228913  1.352917
5  0.886429 -2.001637 -0.371843
6  1.669025 -0.438570 -0.539741

In [32]: df.dropna(thresh=2)
Out[32]:
          0         1         2
2  0.092908       NaN  0.769023
3  1.246435       NaN -1.296221
4  0.274992  0.228913  1.352917
5  0.886429 -2.001637 -0.371843
6  1.669025 -0.438570 -0.539741
```

Filling In Missing Data

```
In [33]: df.fillna(0)
Out[33]:
          0         1         2
0 -0.204708  0.000000  0.000000
1 -0.555730  0.000000  0.000000
2  0.092908  0.000000  0.769023
3  1.246435  0.000000 -1.296221
4  0.274992  0.228913  1.352917
5  0.886429 -2.001637 -0.371843
6  1.669025 -0.438570 -0.539741

In [34]: df.fillna({1: 0.5, 2: 0})
Out[34]:
          0         1         2
0 -0.204708  0.500000  0.000000
1 -0.555730  0.500000  0.000000
2  0.092908  0.500000  0.769023
3  1.246435  0.500000 -1.296221
4  0.274992  0.228913  1.352917
5  0.886429 -2.001637 -0.371843
6  1.669025 -0.438570 -0.539741
```

```
In [35]: _ = df.fillna(0, inplace=True)

In [36]: df
Out[36]:
          0         1         2
0 -0.204708  0.000000  0.000000
1 -0.555730  0.000000  0.000000
2  0.092908  0.000000  0.769023
3  1.246435  0.000000 -1.296221
4  0.274992  0.228913  1.352917
5  0.886429 -2.001637 -0.371843
6  1.669025 -0.438570 -0.539741
```

```
In [37]: df = pd.DataFrame(np.random.randn(6, 3))

In [38]: df.iloc[2:, 1] = NA

In [39]: df.iloc[4:, 2] = NA

In [40]: df
Out[40]:
          0         1         2
0  0.476985  3.248944 -1.021228
1 -0.577087  0.124121  0.302614
2  0.523772       NaN  1.343810
3 -0.713544       NaN -2.370232
4 -1.860761       NaN       NaN
5 -1.265934       NaN       NaN

In [41]: df.fillna(method='ffill')
Out[41]:
          0         1         2
0  0.476985  3.248944 -1.021228
1 -0.577087  0.124121  0.302614
2  0.523772  0.124121  1.343810
3 -0.713544  0.124121 -2.370232
4 -1.860761  0.124121 -2.370232
5 -1.265934  0.124121 -2.370232
```

```
In [42]: df.fillna(method='ffill', limit=2)
Out[42]:
          0         1         2
0  0.476985  3.248944 -1.021228
1 -0.577087  0.124121  0.302614
2  0.523772  0.124121  1.343810
3 -0.713544  0.124121 -2.370232
4 -1.860761       NaN -2.370232
5 -1.265934       NaN -2.370232

In [43]: data = pd.Series([1., NA, 3.5, NA, 7])

In [44]: data.fillna(data.mean())
Out[44]:
0    1.000000
1    3.833333
2    3.500000
3    3.833333
4    7.000000
dtype: float64
```

Table of fillna function arguments

Argument	Description
`value`	Scalar value or dict-like object to use to fill missing values
`method`	Interpolation; by default `'ffill'` if function called with no other arguments
`axis`	Axis to fill on; default `axis=0`
`inplace`	Modify the calling object without producing a copy
`limit`	For forward and backward filling, maximum number of consecutive periods to fill

Data Transformation

Removing Duplicates

```
In [45]: data = pd.DataFrame({'k1': ['one', 'two'] * 3 + ['two'],
    ....:                     'k2': [1, 1, 2, 3, 3, 4, 4]})
```

```
In [46]: data
Out[46]:
    k1  k2
0  one   1
1  two   1
2  one   2
3  two   3
4  one   3
5  two   4
6  two   4
```

```
In [47]: data.duplicated()
Out[47]:
0    False
1    False
2    False
3    False
4    False
5    False
6     True
dtype: bool
```

```
In [48]: data.drop_duplicates()
Out[48]:
    k1  k2
0  one   1
1  two   1
2  one   2
3  two   3
4  one   3
5  two   4
```

```
In [49]: data['v1'] = range(7)

In [50]: data.drop_duplicates(['k1'])
Out[50]:
    k1  k2  v1
0  one   1   0
1  two   1   1


In [51]: data.drop_duplicates(['k1', 'k2'], keep='last')
Out[51]:
    k1  k2  v1
0  one   1   0
1  two   1   1
2  one   2   2
3  two   3   3
4  one   3   4
6  two   4   6
```

Transforming Data Using a Function or Mapping

```
In [52]: data = pd.DataFrame({'food': ['bacon', 'pulled pork', 'bacon',
    ....:                              'Pastrami', 'corned beef', 'Bacon',
    ....:                              'pastrami', 'honey ham', 'nova lox'],
    ....:                     'ounces': [4, 3, 12, 6, 7.5, 8, 3, 5, 6]})
```

```
In [53]: data
Out[53]:
           food  ounces
0         bacon     4.0
1   pulled pork     3.0
2         bacon    12.0
3      Pastrami     6.0
4   corned beef     7.5
5         Bacon     8.0
6      pastrami     3.0
7     honey ham     5.0
8      nova lox     6.0
```

```
meat_to_animal = {
  'bacon': 'pig',
  'pulled pork': 'pig',
  'pastrami': 'cow',
  'corned beef': 'cow',
  'honey ham': 'pig',
  'nova lox': 'salmon'
}
```

```
In [55]: lowercased = data['food'].str.lower()

In [56]: lowercased
Out[56]:
0          bacon
1    pulled pork
2          bacon
3       pastrami
4    corned beef
5          bacon
6       pastrami
7      honey ham
8       nova lox
Name: food, dtype: object
```

```
In [57]: data['animal'] = lowercased.map(meat_to_animal)

In [58]: data
Out[58]:
          food  ounces  animal
0        bacon     4.0     pig
1  pulled pork     3.0     pig
2        bacon    12.0     pig
3     Pastrami     6.0     cow
4  corned beef     7.5     cow
5        Bacon     8.0     pig
6     pastrami     3.0     cow
7    honey ham     5.0     pig
8     nova lox     6.0  salmon
```

```
In [59]: data['food'].map(lambda x: meat_to_animal[x.lower()])
Out[59]:
0       pig
1       pig
2       pig
3       cow
4       cow
5       pig
6       cow
7       pig
8    salmon
Name: food, dtype: object
```

Replacing Values

```
In [60]: data = pd.Series([1., -999., 2., -999., -1000., 3.])
```

```
In [61]: data
Out[61]:
0       1.0
1    -999.0
2       2.0
3    -999.0
4   -1000.0
5       3.0
dtype: float64
```

```
In [62]: data.replace(-999, np.nan)
Out[62]:
0       1.0
1       NaN
2       2.0
3       NaN
4   -1000.0
5       3.0
dtype: float64
```

```
In [63]: data.replace([-999, -1000], np.nan)
Out[63]:
0    1.0
1    NaN
2    2.0
3    NaN
4    NaN
5    3.0
dtype: float64
```

```
In [64]: data.replace([-999, -1000], [np.nan, 0])
Out[64]:
0    1.0
1    NaN
2    2.0
3    NaN
4    0.0
5    3.0
dtype: float64
```

```
In [65]: data.replace({-999: np.nan, -1000: 0})
Out[65]:
0    1.0
1    NaN
2    2.0
3    NaN
4    0.0
5    3.0
dtype: float64
```

Renaming Axis Indexes

```
In [66]: data = pd.DataFrame(np.arange(12).reshape((3, 4)),
    ....:                            index=['Ohio', 'Colorado', 'New York'],
    ....:                            columns=['one', 'two', 'three', 'four'])

In [67]: transform = lambda x: x[:4].upper()

In [68]: data.index.map(transform)
Out[68]: Index(['OHIO', 'COLO', 'NEW '], dtype='object')

In [69]: data.index = data.index.map(transform)

In [70]: data
Out[70]:
      one  two  three  four
OHIO    0    1      2     3
COLO    4    5      6     7
NEW     8    9     10    11
```

```
In [71]: data.rename(index=str.title, columns=str.upper)
Out[71]:
      ONE  TWO  THREE  FOUR
Ohio    0    1      2     3
Colo    4    5      6     7
New     8    9     10    11
```

Detecting and Filtering Outliers

```
In [92]: data = pd.DataFrame(np.random.randn(1000, 4))

In [93]: data.describe()
Out[93]:
                 0            1            2            3
count  1000.000000  1000.000000  1000.000000  1000.000000
mean      0.049091     0.026112    -0.002544    -0.051827
std       0.996947     1.007458     0.995232     0.998311
min      -3.645860    -3.184377    -3.745356    -3.428254
25%      -0.599807    -0.612162    -0.687373    -0.747478
50%       0.047101    -0.013609    -0.022158    -0.088274
75%       0.756646     0.695298     0.699046     0.623331
max       2.653656     3.525865     2.735527     3.366626

In [94]: col = data[2]

In [95]: col[np.abs(col) > 3]
Out[95]:
41    -3.399312
136   -3.745356
Name: 2, dtype: float64
```

```
In [96]: data[(np.abs(data) > 3).any(1)]
Out[96]:
            0         1         2         3
41   0.457246 -0.025907 -3.399312 -0.974657
60   1.951312  3.260383  0.963301  1.201206
136  0.508391 -0.196713 -3.745356 -1.520113
235 -0.242459 -3.056990  1.918403 -0.578828
258  0.682841  0.326045  0.425384 -3.428254
322  1.179227 -3.184377  1.369891 -1.074833
544 -3.548824  1.553205 -2.186301  1.277104
635 -0.578093  0.193299  1.397822  3.366626
782 -0.207434  3.525865  0.283070  0.544635
803 -3.645860  0.255475 -0.549574 -1.907459
```

```
In [97]: data[np.abs(data) > 3] = np.sign(data) * 3

In [98]: data.describe()
Out[98]:
                 0            1            2            3
count  1000.000000  1000.000000  1000.000000  1000.000000
mean      0.050286     0.025567    -0.001399    -0.051765
std       0.992920     1.004214     0.991414     0.995761
min      -3.000000    -3.000000    -3.000000    -3.000000
25%      -0.599807    -0.612162    -0.687373    -0.747478
50%       0.047101    -0.013609    -0.022158    -0.088274
75%       0.756646     0.695298     0.699046     0.623331
max       2.653656     3.000000     2.735527     3.000000

In [99]: np.sign(data).head()
Out[99]:
     0    1    2    3
0 -1.0  1.0 -1.0  1.0
1  1.0 -1.0  1.0 -1.0
2  1.0  1.0  1.0 -1.0
3 -1.0 -1.0  1.0 -1.0
4 -1.0  1.0 -1.0 -1.0
```

Computing Indicator/Dummy Variables

```
In [109]: df = pd.DataFrame({'key': ['b', 'b', 'a', 'c', 'a', 'b'],
   .....:                    'data1': range(6)})

In [110]: pd.get_dummies(df['key'])
Out[110]:
   a  b  c
0  0  1  0
1  0  1  0
2  1  0  0
3  0  0  1
4  1  0  0
5  0  1  0
```

```
In [111]: dummies = pd.get_dummies(df['key'], prefix='key')

In [112]: df_with_dummy = df[['data1']].join(dummies)

In [113]: df_with_dummy
Out[113]:
   data1  key_a  key_b  key_c
0      0      0      1      0
1      1      0      1      0
2      2      1      0      0
3      3      0      0      1
4      4      1      0      0
5      5      0      1      0
```

```
In [114]: mnames = ['movie_id', 'title', 'genres']

In [115]: movies = pd.read_table('datasets/movielens/movies.dat', sep='::',
   .....:                        header=None, names=mnames)

In [116]: movies[:10]
Out[116]:
   movie_id                               title                        genres
0         1                    Toy Story (1995)   Animation|Children's|Comedy
1         2                      Jumanji (1995)  Adventure|Children's|Fantasy
2         3             Grumpier Old Men (1995)                Comedy|Romance
3         4            Waiting to Exhale (1995)                  Comedy|Drama
4         5  Father of the Bride Part II (1995)                        Comedy
5         6                           Heat (1995)         Action|Crime|Thriller
6         7                        Sabrina (1995)                Comedy|Romance
7         8                Tom and Huck (1995)          Adventure|Children's
8         9                Sudden Death (1995)                        Action
9        10                   GoldenEye (1995)      Action|Adventure|Thriller

In [117]: all_genres = []

In [118]: for x in movies.genres:
   .....:     all_genres.extend(x.split('|'))

In [119]: genres = pd.unique(all_genres)
```

```
In [120]: genres
Out[120]:
array(['Animation', "Children's", 'Comedy', 'Adventure', 'Fantasy',
       'Romance', 'Drama', 'Action', 'Crime', 'Thriller', 'Horror',
       'Sci-Fi', 'Documentary', 'War', 'Musical', 'Mystery', 'Film-Noir',
       'Western'], dtype=object)
```

```
In [121]: zero_matrix = np.zeros((len(movies), len(genres)))

In [122]: dummies = pd.DataFrame(zero_matrix, columns=genres)

In [123]: gen = movies.genres[0]

In [124]: gen.split('|')
Out[124]: ['Animation', "Children's", 'Comedy']

In [125]: dummies.columns.get_indexer(gen.split('|'))
Out[125]: array([0, 1, 2])
```

```
In [126]: for i, gen in enumerate(movies.genres):
   .....:     indices = dummies.columns.get_indexer(gen.split('|'))
   .....:     dummies.iloc[i, indices] = 1
   .....:
```

```
In [127]: movies_windic = movies.join(dummies.add_prefix('Genre_'))

In [128]: movies_windic.iloc[0]
Out[128]:
movie_id                                  1
title                      Toy Story (1995)
genres             Animation|Children's|Comedy
Genre_Animation                           1
Genre_Children's                          1
Genre_Comedy                              1
Genre_Adventure                           0
Genre_Fantasy                             0
Genre_Romance                             0
Genre_Drama                               0
                                        ...
Genre_Crime                               0
Genre_Thriller                            0
Genre_Horror                              0
Genre_Sci-Fi                              0
Genre_Documentary                         0
Genre_War                                 0
Genre_Musical                             0
Genre_Mystery                             0
Genre_Film-Noir                           0
Genre_Western                             0
Name: 0, Length: 21, dtype: object
```

String Manipulation

String Object Methods

```
In [134]: val = 'a,b,  guido'

In [135]: val.split(',')
Out[135]: ['a', 'b', '  guido']

In [136]: pieces = [x.strip() for x in val.split(',')]

In [137]: pieces
Out[137]: ['a', 'b', 'guido']

In [138]: first, second, third = pieces

In [139]: first + '::' + second + '::' + third
Out[139]: 'a::b::guido'
```

```
In [140]: '::'.join(pieces)
Out[140]: 'a::b::guido'

In [141]: 'guido' in val
Out[141]: True

In [142]: val.index(',')
Out[142]: 1

In [143]: val.find(':')
Out[143]: -1

In [145]: val.count(',')
Out[145]: 2

In [146]: val.replace(',', '::')
Out[146]: 'a::b::  guido'

In [147]: val.replace(',', '')
Out[147]: 'ab  guido'
```

Python built-in string methods

Argument	Description
`count`	Return the number of non-overlapping occurrences of substring in the string.
`endswith`	Returns `True` if string ends with suffix.
`startswith`	Returns `True` if string starts with prefix.
`join`	Use string as delimiter for concatenating a sequence of other strings.
`index`	Return position of first character in substring if found in the string; raises `ValueError` if not found.
`find`	Return position of first character of *first* occurrence of substring in the string; like `index`, but returns –1 if not found.
`rfind`	Return position of first character of *last* occurrence of substring in the string; returns –1 if not found.
`replace`	Replace occurrences of string with another string.
`strip`, `rstrip`, `lstrip`	Trim whitespace, including newlines; equivalent to `x.strip()` (and `rstrip, lstrip`, respectively) for each element.
`split`	Break string into list of substrings using passed delimiter.
`lower`	Convert alphabet characters to lowercase.
`upper`	Convert alphabet characters to uppercase.
`casefold`	Convert characters to lowercase, and convert any region-specific variable character combinations to a common comparable form.
`ljust`, `rjust`	Left justify or right justify, respectively; pad opposite side of string with spaces (or some other fill character) to return a string with a minimum width.

Regular expression methods

Argument	Description
`findall`	Return all non-overlapping matching patterns in a string as a list
`finditer`	Like `findall`, but returns an iterator
`match`	Match pattern at start of string and optionally segment pattern components into groups; if the pattern matches, returns a match object, and otherwise None
`search`	Scan string for match to pattern; returning a match object if so; unlike `match`, the match can be anywhere in the string as opposed to only at the beginning
`split`	Break string into pieces at each occurrence of pattern
`sub, subn`	Replace all (`sub`) or first n occurrences (`subn`) of pattern in string with replacement expression; use symbols `\1, \2, ...` to refer to match group elements in the replacement string

Vectorized String Functions in pandas

```
In [167]: data = {'Dave': 'dave@google.com', 'Steve': 'steve@gmail.com',
   .....:         'Rob': 'rob@gmail.com', 'Wes': np.nan}

In [168]: data = pd.Series(data)

In [169]: data
Out[169]:
Dave     dave@google.com
Rob        rob@gmail.com
Steve    steve@gmail.com
Wes                  NaN
dtype: object

In [170]: data.isnull()
Out[170]:
Dave     False
Rob      False
Steve    False
Wes       True
dtype: bool
```

```
In [171]: data.str.contains('gmail')
Out[171]:
Dave     False
Rob       True
Steve     True
Wes        NaN
dtype: object

In [172]: pattern
Out[172]: '([A-Z0-9._%+-]+)@([A-Z0-9.-]+)\\.([A-Z]{2,4})'

In [173]: data.str.findall(pattern, flags=re.IGNORECASE)
Out[173]:
Dave     [(dave, google, com)]
Rob        [(rob, gmail, com)]
Steve    [(steve, gmail, com)]
Wes                        NaN
dtype: object
```

```
In [174]: matches = data.str.match(pattern, flags=re.IGNORECASE)

In [175]: matches
Out[175]:
Dave     True
Rob      True
Steve    True
Wes       NaN
dtype: object

In [176]: matches.str.get(1)
Out[176]:
          Dave    NaN
          Rob     NaN
          Steve   NaN
          Wes     NaN
          dtype: float64

          In [177]: matches.str[0]
          Out[177]:
          Dave    NaN
          Rob     NaN
          Steve   NaN
          Wes     NaN
          dtype: float64
```

```
In [178]: data.str[:5]
Out[178]:
Dave     dave@
Rob      rob@g
Steve    steve
Wes        NaN
dtype: object
```

Method	Description
`cat`	Concatenate strings element-wise with optional delimiter
`contains`	Return boolean array if each string contains pattern/regex
`count`	Count occurrences of pattern
`extract`	Use a regular expression with groups to extract one or more strings from a Series of strings; the result will be a DataFrame with one column per group
`endswith`	Equivalent to `x.endswith(pattern)` for each element
`startswith`	Equivalent to `x.startswith(pattern)` for each element
`findall`	Compute list of all occurrences of pattern/regex for each string
`get`	Index into each element (retrieve *i*-th element)
`isalnum`	Equivalent to built-in `str.alnum`
`isalpha`	Equivalent to built-in `str.isalpha`
`isdecimal`	Equivalent to built-in `str.isdecimal`
`isdigit`	Equivalent to built-in `str.isdigit`
`islower`	Equivalent to built-in `str.islower`
`isnumeric`	Equivalent to built-in `str.isnumeric`
`isupper`	Equivalent to built-in `str.isupper`
`join`	Join strings in each element of the Series with passed separator
`len`	Compute length of each string
`lower, upper`	Convert cases; equivalent to `x.lower()` or `x.upper()` for each element

Method	Description
`match`	Use `re.match` with the passed regular expression on each element, returning matched groups as list
`pad`	Add whitespace to left, right, or both sides of strings
`center`	Equivalent to `pad(side='both')`
`repeat`	Duplicate values (e.g., `s.str.repeat(3)` is equivalent to `x * 3` for each string)
`replace`	Replace occurrences of pattern/regex with some other string
`slice`	Slice each string in the Series
`split`	Split strings on delimiter or regular expression
`strip`	Trim whitespace from both sides, including newlines
`rstrip`	Trim whitespace on right side
`lstrip`	Trim whitespace on left side