Programming Principles in Python (CSCI 503/490)

Data

Dr. David Koop





pandas

- Contains high-level data structures and manipulation tools designed to make data analysis fast and easy in Python
- Built on top of NumPy
- Built with the following requirements:
 - Data structures with labeled axes (aligning data)
 - Support time series data
 - Do arithmetic operations that include metadata (labels)
 - Handle missing data
 - Add merge and relational operations









Series

- A one-dimensional array (with a type) with an **index**
- Index defaults to numbers but can also be text (like a dictionary)
- Allows easier reference to specific items
- obj = pd.Series([7,14,-2,1])
- Basically two arrays: obj.values and obj.index
- Can specify the index explicitly and use strings
- obj2 = pd.Series([4, 7, -5, 3])index=['d', 'b', 'a', 'c'])
- Kind of like fixed-length, ordered dictionary + can create from a dictionary
- obj3 = pd.Series({'Ohio': 35000, 'Texas': 71000,

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'Oregon': 16000, 'Utah': 5000})



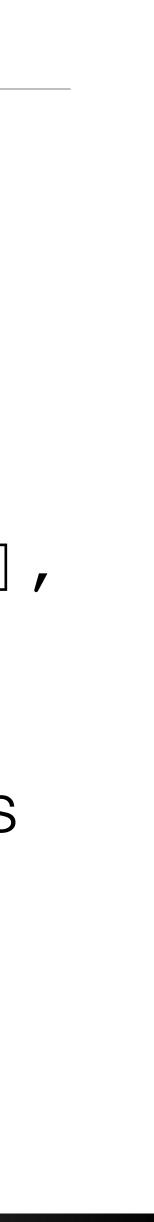






- A dictionary of Series (labels for each series) A spreadsheet with row keys (the index) and column headers
- Has an index shared with each series
- Allows easy reference to any cell
- df = DataFrame({'state': ['Ohio', 'Ohio', 'Ohio', 'Nevada'], 'year': [2000, 2001, 2002, 2001], 'pop': [1.5, 1.7, 3.6, 2.4]})
- Index is automatically assigned just as with a series but can be passed in as well via index kwarg
- Can reassign column names by passing columns kwarg





DataFrame Access and Manipulation

- df.values \rightarrow 2D NumPy array
- Accessing a column:
 - df["<column>"]
 - df.<column>
 - Both return Series
 - Dot syntax only works when the column is a valid identifier
- Assigning to a column:
 - df["<column>"] = <scalar> # all cells set to same value
 - df["<column>"] = <array> # values set in order
 - df["<column>"] = <series> # values set according to match between df and series indexes









Indexing

- Same as with NumPy arrays but can use Series's index labels
- Slicing with labels: NumPy is **exclusive**, Pandas is **inclusive**!
 - s = Series(np.arange(4))
 - s[0:2] # gives two values like numpy - s = Series(np.arange(4), index=['a', 'b', 'c', 'd'])s['a':'c'] # gives three values, not two!
- Obtaining data subsets
 - [...]: get columns by label
 - loc[...]: get rows/cols by label
 - iloc[...]: get rows/cols by position (integer index)
- For single cells (scalars), also have at and iat









df =	<pre>df = pd.read_csv('penguins_lter.csv')</pre>										
	studyName	Sample Number	Species	Region	Island	Stage	Individual ID	Clutch Completion	Date Egg	Culmen Length (mm)	
0	PAL0708	1	Adelie Penguin (Pygoscelis adeliae)	Anvers	Torgersen	Adult, 1 Egg Stage	N1A1	Yes	11/11/07	39.1	
1	PAL0708	2	Adelie Penguin (Pygoscelis adeliae)	Anvers	Torgersen	Adult, 1 Egg Stage	N1A2	Yes	11/11/07	39.5	
2	PAL0708	3	Adelie Penguin (Pygoscelis adeliae)	Anvers	Torgersen	Adult, 1 Egg Stage	N2A1	Yes	11/16/07	40.3	
3	PAL0708	4	Adelie Penguin (Pygoscelis adeliae)	Anvers	Torgersen	Adult, 1 Egg Stage	N2A2	Yes	11/16/07	NaN	
4	PAL0708	5	Adelie Penguin (Pygoscelis adeliae)	Anvers	Torgersen	Adult, 1 Egg Stage	N3A1	Yes	11/16/07	36.7	
339	PAL0910	120	Gentoo penguin (Pygoscelis papua)	Anvers	Biscoe	Adult, 1 Egg Stage	N38A2	No	12/1/09	NaN	
340	PAL0910	121	Gentoo penguin (Pygoscelis papua)	Anvers	Biscoe	Adult, 1 Egg Stage	N39A1	Yes	11/22/09	46.8	
341	PAL0910	122	Gentoo penguin (Pygoscelis papua)	Anvers	Biscoe	Adult, 1 Egg Stage	N39A2	Yes	11/22/09	50.4	
342	PAL0910	123	Gentoo penguin (Pygoscelis papua)	Anvers	Biscoe	Adult, 1 Egg Stage	N43A1	Yes	11/22/09	45.2	
343	PAL0910	124	Gentoo penguin (Pygoscelis papua)	Anvers	Biscoe	Adult, 1 Egg Stage	N43A2	Yes	11/22/09	49.9	

344 rows × 17 columns





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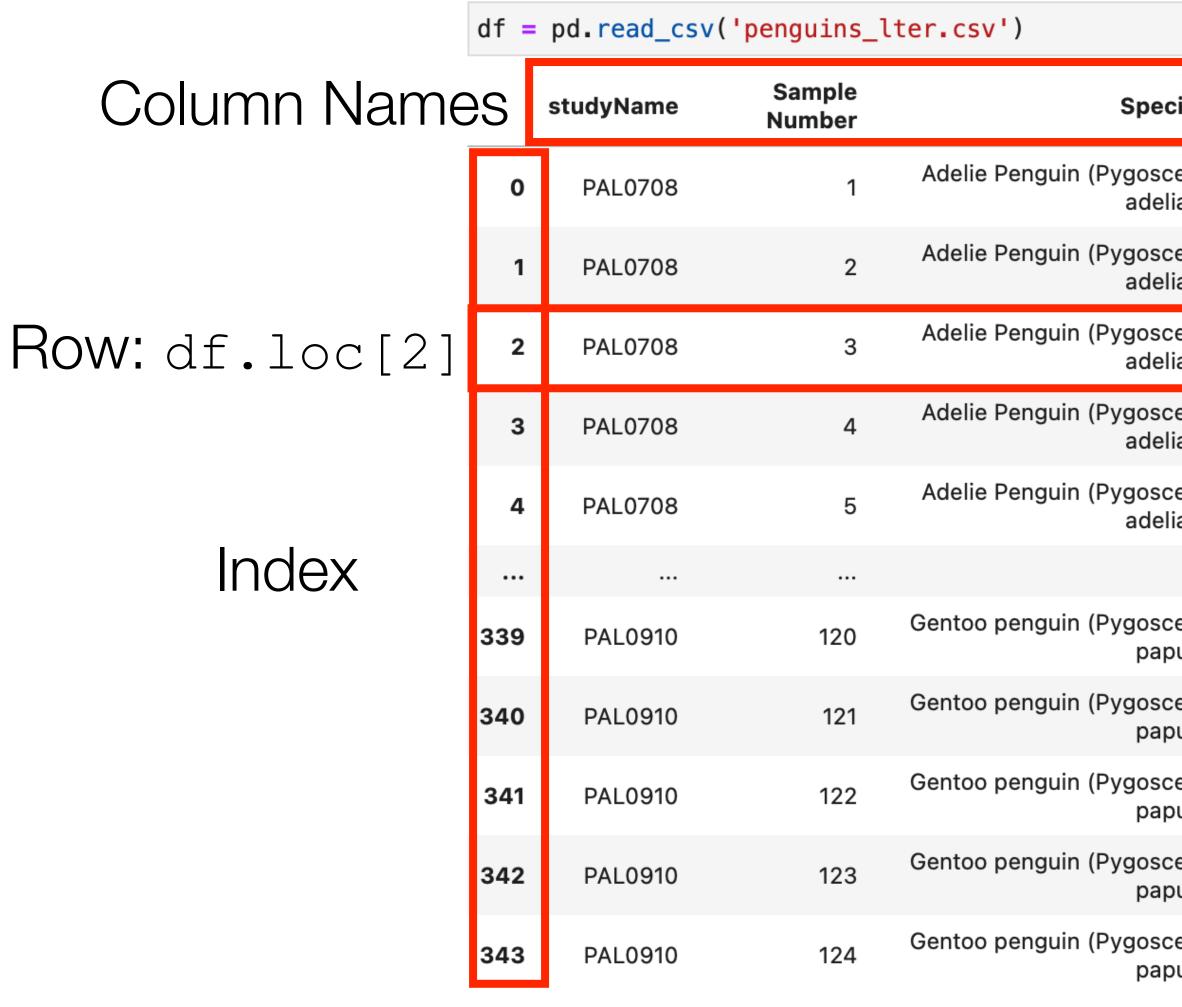
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Column: df['Island']





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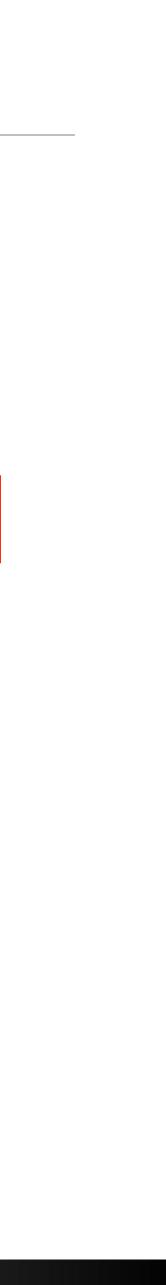
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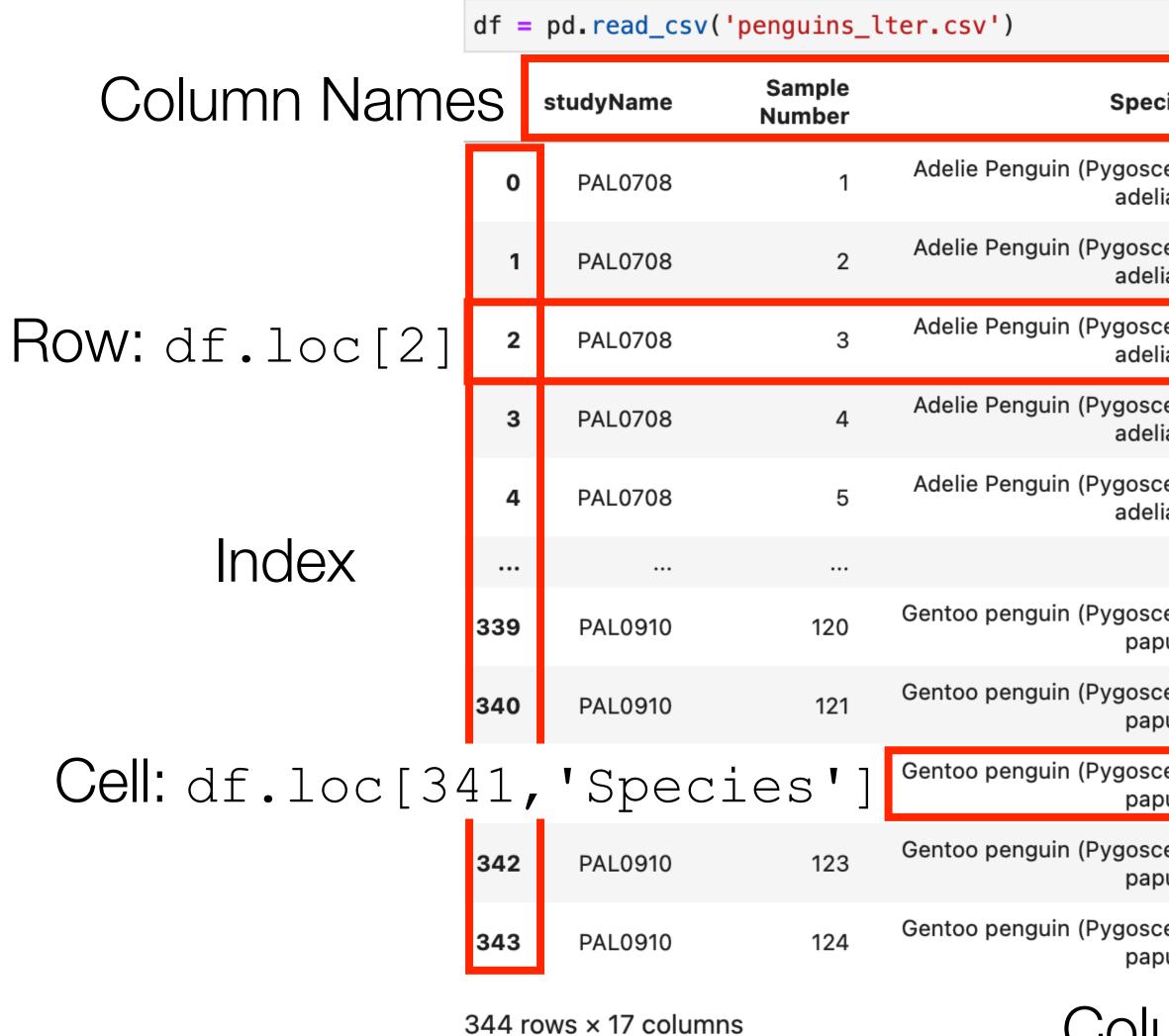
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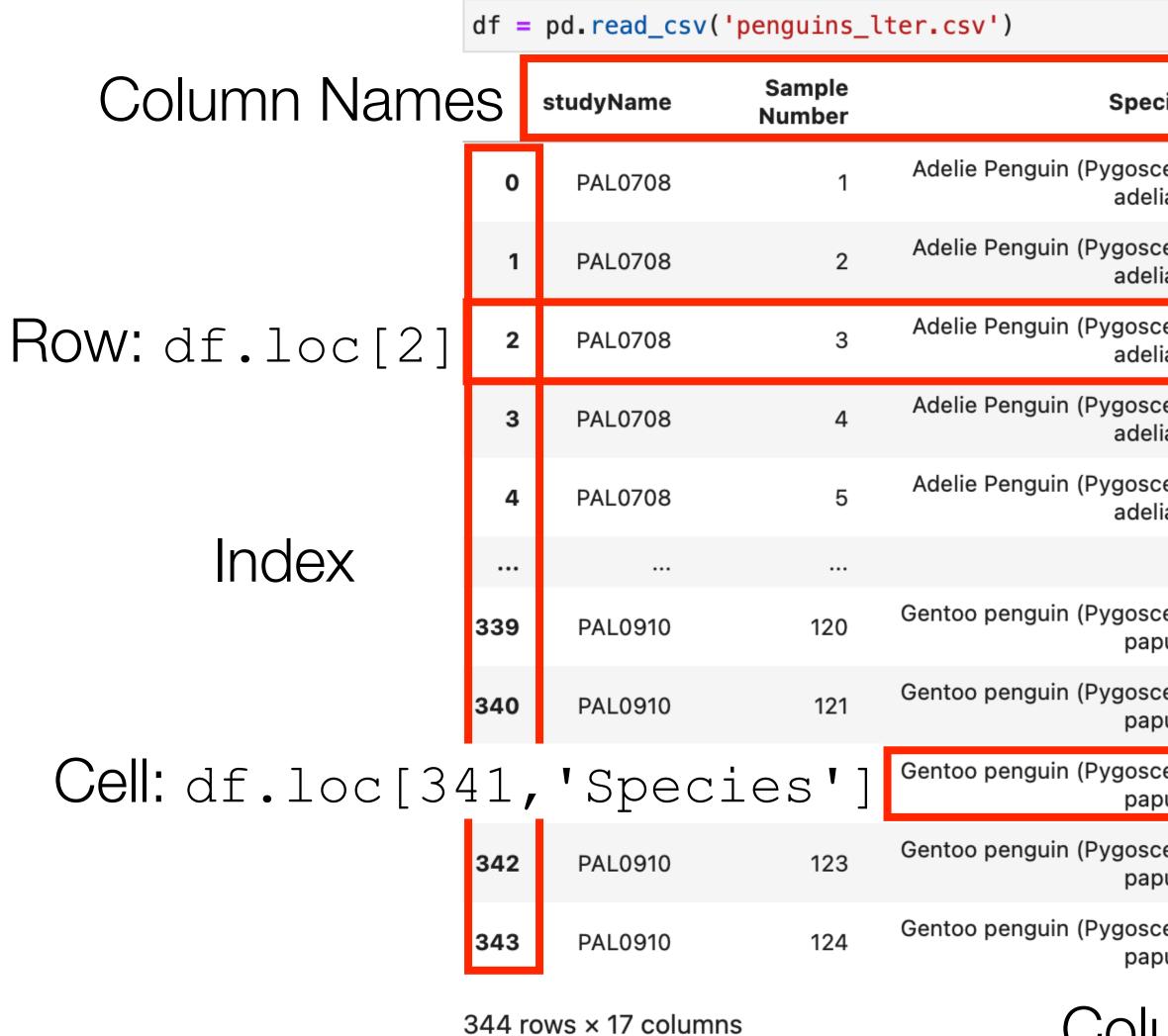
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<u>Assignment 7</u>

- Musical Artists Datasets
- Downloading and uncompressing files
- Finding files using OS libraries
- Load per-artist numpy arrays, each saved in the .npy format
- Store per-month dataframes, each in a csv file







Arithmetic

- Add, subtract, multiply, and divide are element-wise like numpy
- ...but use labels to align
- ...and missing labels lead to NaN (not a number) values

In [28]:	obj3	In [29]: obj	4	In [30]: obj3 + obj4		
Out[28]:		Out[29]:		Out[30]:		
Ohio	35000	California	NaN	California	NaN	
Oregon	16000	Ohio	35000	Ohio	70000	
Texas	71000	Oregon	16000	Oregon	32000	
Utah	5000	Texas	71000	Texas	142000	
dtype: int64		dtype: float	64	Utah	NaN	
				dtype: float	64	

- also have .add, .subtract, ... that allow fill value argument
- obj3.add(obj4, fill value=0)







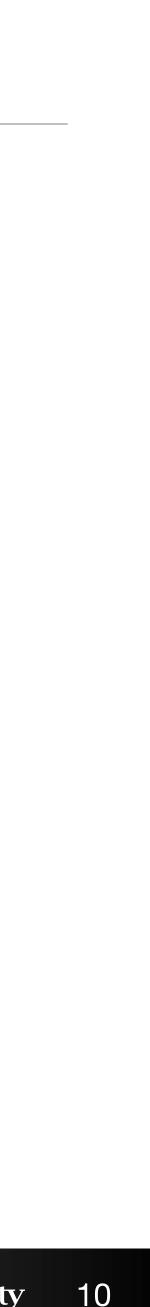
Filtering

- Same as with numpy arrays but allows use of column-based criteria
 - data [data < 5] = 0
 - data[data['three'] > 5]
- Multiple criteria, use &, \mid , and \sim ; remember parentheses!
- Also can check for missing values via isna()/isnull()/notnull()
 - data[data['three'].notnull() & data['two'].isnull()]

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• data < 5 \rightarrow boolean data frame, can be used to select specific elements - data[(data['three'] > 5) & (data['two'] < 10)]





Filtering

df[df['Culmen Length (mm)'] > 40]

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DataFrame Index

- Similar to index for Series
- Immutable
- Can be shared with multiple structures (DataFrames or Series)
- in operator works with: 'Ohio' in df.index
- \bullet Can choose new index column(s) with <code>set_index()</code>
- reindex creates a new object with the data conformed to new index
 - obj2 = obj.reindex(['a', 'b', 'c', 'd', 'e'])
 - can fill in missing values in different ways





Sorting

- sort values method on series - obj.sort values()
- first)
- sort values on DataFrame:
 - df.sort values (<list-of-columns>)
 - df.sort values(by=['a', 'b'])
- Also a sort index method to sort by the index
 - df.sort index()

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• Missing values (NaN) are at the end by default (na position controls, can be







Statistics

- sum: column sums (axis=1 gives sums over rows)
- missing values are excluded unless the whole slice is NaN
- idxmax, idxmin are like argmax, argmin (return index)
- describe: shortcut for easy stats!

In	[204]:	<pre>df.describe()</pre>	In [2
Out	[204]:		_

top

freq

	one	two	
count	3.000000	2.000000	
mean	3.083333	-2.900000	
std	3.493685	2.262742	
min	0.750000	-4.500000	
25%	1.075000	-3.700000	
50%	1.400000	-2.900000	
75%	4.250000	-2.100000	
max	7.100000	-1.300000	

```
205]: obj = Series(['a', 'a', 'b', 'c'] * 4)
In [206]: obj.describe()
Out[206]:
count
        16
unique
           3
           а
           8
dtype: object
```





Unique Values and Value Counts

- unique() returns an array with only the unique values (no index)
 - s = Series(['c','a','d','a','a','b','b','c','c'])
 s.unique() # array(['c', 'a', 'd', 'b'])
- Also nunique() to count number of unique entries
- Data Frames use drop_duplicates
- value_counts returns a Series with index frequencies:
 - s.value_counts() # Series({'c': 3,'a': 3,'b': 2,'d': 1})





Reading & Writing Data in Pandas

Format	Data Description
text	<u>CSV</u>
text	Fixed-Width Text File
text	<u>JSON</u>
text	HTML
text	Local clipboard
	MS Excel
binary	<u>OpenDocument</u>
binary	HDF5 Format
binary	Feather Format
binary	Parquet Format
binary	ORC Format
binary	<u>Msgpack</u>
binary	<u>Stata</u>
binary	<u>SAS</u>
binary	<u>SPSS</u>
binary	Python Pickle Format
SQL	SQL
SQL	Google BigQuery

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Reader	Writer
read_csv	to_csv
read_fwf	
read_json	to_json
read_html	to_html
read_clipboard	to_clipboard
read_excel	to_excel
read_excel	
read_hdf	to_hdf
read_feather	to_feather
read_parquet	to_parquet
read_orc	
read_msgpack	to_msgpack
read_stata	to_stata
read_sas	
read_spss	
read_pickle	to_pickle
read_sql	to_sql
read_gbq	to_gbq

[https://pandas.pydata.org/pandas-docs/stable/user_guide/io.html]











read CSV

- Convenient method to read csv files
- Lots of different options to help get data into the desired format
- **Basic:** df = pd.read csv(fname)
- Parameters:

 - path: where to read the data from - sep (Or delimiter): the delimiter $(', ', '', '', ' \setminus t', ' \setminus s+')$
 - header: if None, no header
 - index col: which column to use as the row index - names: list of header names (e.g. if the file has no header)

 - skiprows: number of list of lines to skip





Writing CSV data with pandas

- Basic: df.to csv(<fname>)
- Change delimiter with sep kwarg:
 - df.to csv('example.dsv', sep='|')
- Change missing value representation - df.to csv('example.dsv', na rep='NULL')
- Don't write row or column labels:
 - df.to csv('example.csv', index=False, header=False)
- Series may also be written to csv







Handling Missing Data

Argument	Description
dropna	Filter axis labels based on whether values for missing data to tolerate.
fillna	Fill in missing data with some value or using
isnull	Return like-type object containing boolean v
notnull	Negation of isnull.

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r each label have missing data, with varying thresholds for how much

g an interpolation method such as 'ffill' or 'bfill'. values indicating which values are missing / NA.

[W. McKinney, Python for Data Analysis]











Derived Data

- Create new columns from existing columns
 - r["PctFail"] = r['Fail'] / r['Total']
 - r = r.assign(PctFail= r['Fail'] / r['Total'])
- Note that operations are computed in a vectorized manner
- Similarities to functional paradigm (map/filter):
 - specify the operation once
 - no loops
 - interpreted as an operation on the entire column



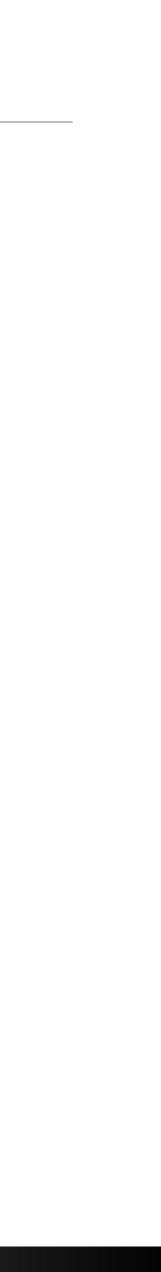




inplace

- Generally, when we modify a data frame, we reassign:
 - rdf = df.reset index()
 - This is usually very efficient
 - Allows for method chaining
- There are versions where you can do this "inplace":
 - df.reset index (inplace=True)
 - This means no reassignment, but it isn't usually any faster nor better
 - Sometimes still creates a copy
 - Will likely be <u>deprecated</u>









Documentation

- pandas <u>documentation</u> is pretty good

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Lots of recipes on stackoverflow for particular data manipulations/queries







