DATA AND AI

Pandas Cheat Sheet

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Cheat Sheet: The pandas DataFrame Object

Preliminaries

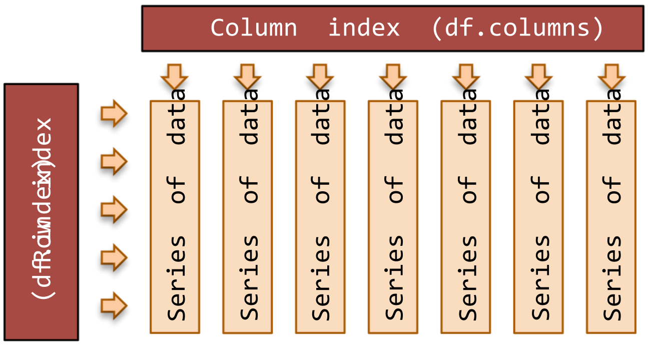
Start by importing these Python modules

```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
from pandas import DataFrame, Series
```

Note: these are the recommended import aliases

The conceptual model

DataFrame object: The pandas DataFrame is a two-dimensional table of data with column and row indexes. The columns are made up of pandas Series objects.



Series object : an ordered, one-dimensional array of data with an index. All the data in a Series is of the same data type. Series arithmetic is vectorised after first aligning the Series index for each of the operands.

```
s1 = Series(range(0,4)) # -> 0, 1, 2, 3 s2 =
Series(range(1,5)) # -> 1, 2, 3, 4 s3 = s1 + s2 # ->
1, 3, 5, 7 s4 = Series(['a','b'])*3 # -> 'aaa','bbb'
```

The index object: The pandas Index provides the axis labels for the Series and DataFrame objects. It can only contain hashable objects. A pandas Series has one Index; and a DataFrame has two Indexes.

```
# --- get Index from Series and DataFrame
idx = s.index idx = df.columns idx = df.index


                    # the column index
                    # the row index

# --- some Index attributes b =
idx.is_monotonic_decreasing b =
idx.is_monotonic_increasing b =
idx.has_duplicates
i = idx.nlevels     # multi-level indexes

# --- some Index methods
a = idx.values() l = # get as numpy array
idx.tolist()        # get as a python list
idx = idx.astype(dtype)# change data type
b = idx.equals(o)   # check for equality
idx = idx.union(o) # union of two indexes
i = idx.nunique() # number unique labels
label = idx.min() # minimum label #
label = idx.max()   maximum label
```

Get your data into a DataFrame

Load a DataFrame from a CSV file

```
df = pd.read_csv('file.csv')# often works
df = pd.read_csv('file.csv', header=0,
      index_col=0, quotechar='"',sep=':',
      na_values = ['na', '-', '.', ''])
```

Note: refer to pandas docs for all arguments

From inline CSV text to a DataFrame

```
from StringIO import StringIO # python2.7
#from io import StringIO         # python 3
data = """, Animal, Cuteness, Desirable
row-1,       dog,     8.7,       True
row-2,       bat,     2.6,       False"""
df = pd.read_csv(StringIO(data),
      header=0,    index_col=0,
      skipinitialspace=True)
```

Note: *skipinitialspace=True* allows a pretty layout

Load DataFrames from a Microsoft Excel file

```
# Each Excel sheet in a Python dictionary
workbook = pd.ExcelFile('file.xlsx')
dictionary = {}
for sheet_name in workbook.sheet_names:
df = workbook.parse(sheet_name)
dictionary[sheet_name] = df
```

Note: the parse() method takes many arguments like read_csv() above. Refer to the pandas documentation.

Load a DataFrame from a MySQL database

```
import pymysql
from sqlalchemy import create_engine
engine = create_engine('mysql+pymysql://'
    +'USER:PASSWORD@localhost/DATABASE')
df = pd.read_sql_table('table', engine)
```

Data in Series then combine into a DataFrame

```
# Example 1 ...
s1 = Series(range(6))
s2 = s1 * s1
s2.index = s2.index + 2# misalign indexes
df = pd.concat([s1, s2], axis=1)


# Example 2 ... s3 = Series({'Tom':1, 'Dick':4,
'Har':9}) s4 = Series({'Tom':3, 'Dick':2, 'Mar':5})
df = pd.concat({'A':s3, 'B':s4 }, axis=1)
```

Note: 1st method has in integer column labels
Note: 2nd method does not guarantee col order
Note: index alignment on DataFrame creation

Get a DataFrame from data in a Python dictionary

```
# default --- assume data is in columns
df = DataFrame({
        'col0' : [1.0, 2.0, 3.0, 4.0],
        'col1' : [100, 200, 300, 400]
    })
```

Get a DataFrame from data in a Python dictionary

```
# --- use helper method for data in rows
df = DataFrame.from_dict({ # data by row
'row0' : {'col0':0, 'col1':'A'},
'row1' : {'col0':1, 'col1':'B'}
      }, orient='index')

df = DataFrame.from_dict({ # data by row
'row0' : [1, 1+1j, 'A'],
'row1' : [2, 2+2j, 'B']
      }, orient='index')
```

Create play/fake data (useful for testing)

```
# --- simple
df = DataFrame(np.random.rand(50,5))

# --- with a time-stamp row index:
df = DataFrame(np.random.rand(500,5))
df.index = pd.date_range('1/1/2006',
           periods=len(df), freq='M')

# --- with alphabetic row and col indexes
import string import random r = 52 # note:
min r is 1; max r is 52 c = 5 df =
DataFrame(np.random.randn(r, c),


           columns = ['col'+str(i) for i in
                      range(c)],
              index = list((string.uppercase +
                   string.lowercase)[0:r]))
df['group'] = list(
     ''.join(random.choice('abcd')
          for _ in range(r))
     )
```

Saving a DataFrame

Saving a DataFrame to a CSV file

```
df.to_csv('name.csv', encoding='utf-8')
```

Saving DataFrames to an Excel Workbook

```
from pandas import ExcelWriter writer =
ExcelWriter('filename.xlsx')
df1.to_excel(writer,'Sheet1')
df2.to_excel(writer,'Sheet2') writer.save()
```

Saving a DataFrame to MySQL

```
import pymysql
from sqlalchemy import create_engine
e = create_engine('mysql+pymysql://' +
     'USER:PASSWORD@localhost/DATABASE')
df.to_sql('TABLE',e, if_exists='replace')
```

Note: if_exists ! 'fail', 'replace', 'append'

Saving a DataFrame to a Python dictionary

```
dictionary = df.to_dict()
```

Saving a DataFrame to a Python string

```
string = df.to_string()
```

Note: sometimes may be useful for debugging

Working with the whole DataFrame

Peek at the DataFrame contents

```
df.info()  n = 4 dfh      # index & data types
= df.head(n)  dft =
df.tail(n)                # get first n rows
                          # get last n rows
dfs = df.describe() # summary stats cols
top_left_corner_df = df.iloc[:5, :5]
```

DataFrame non-indexing attributes

```
dfT = df.T          # transpose rows and cols
l = df.axes         # list row and col indexes
(r, c) = df.axes       # from above
s = df.dtypes # Series column data types
b = df.empty    # True for empty DataFrame
i = df.ndim     # number of axes (2)
t = df.shape    # (row-count, column-count)
(r, c) = df.shape # from above
i = df.size # row-count * column-count a = df.values #
get a numpy array for df
```

DataFrame utility methods

```
dfc = df.copy() # copy a DataFrame dfr =
df.rank() # rank each col (default) dfs =
df.sort() # sort each col (default) dfc =
df.astype(dtype) # type conversion
```

DataFrame iteration methods

```
df.iteritems()# (col-index, Series) pairs
df.iterrows() # (row-index, Series) pairs


# example ... iterating over columns
for (name, series) in df.iteritems():
    print('Col name: ' + str(name))
    print('First value: ' +
         str(series.iat[0]) + '\n')
```

Maths on the whole DataFrame (not a complete list)

```
df = df.abs()       # absolute values
df = df.add(o) # add df, Series or value
s = df.count() # non NA/null values
df = df.cummax() # (cols default axis)
df = df.cummin() # (cols default axis)
df = df.cumsum() # (cols default axis)
df = df.cumprod() # (cols default axis)
df = df.diff() # 1st diff (col def axis)
df = df.div(o) # div by df, Series, value
df = df.dot(o) # matrix dot product
s = df.max()       # max of axis (col def)
s = df.mean()      # mean (col default axis)
s = df.median()# median (col default)
s = df.min()       # min of axis (col def)
df = df.mul(o) # mul by df Series val
s = df.sum()       # sum axis (cols default)
```

Note: The methods that return a series default to working on columns.

DataFrame filter/select rows or cols on label info

```
df = df.filter(items=['a', 'b']) # by col df =
df.filter(items=[5], axis=0) #by row df =
df.filter(like='x') # keep x in col df =
df.filter(regex='x') # regex in col df =
df.select(crit=(lambda x:not x%5))#r
```

Note: select takes a Boolean function, for cols: axis=1

Note: filter defaults to cols; select defaults to rows

Working with Columns

A DataFrame column is a pandas Series object

Get column index and labels

```
idx = df.columns # get col index label =
df.columns[0] # 1st col label lst =
df.columns.tolist() # get as a list
```

Change column labels

```
df.rename(columns={'old':'new'},
    inplace=True)
df = df.rename(columns={'a':1,'b':'x'})
```

Selecting columns

```
s = df['colName'] # select col to Series
df = df[['colName']] # select col to df
df = df[['a','b']]          # select 2 or more
df = df[['c','a','b']]# change order
s = df[df.columns[0]] # select by number
df = df[df.columns[[0, 3, 4]] # by number
s = df.pop('c') # get col & drop from df
```

Selecting columns with Python attributes

```
s = df.a               # same as s = df['a']
# cannot create new columns by attribute
df.existing_col = df.a / df.b
df['new_col'] = df.a / df.b
```

Trap: column names must be valid identifiers.

Adding new columns to a DataFrame

```
df['new_col'] = range(len(df))
df['new_col'] = np.repeat(np.nan,len(df))
df['random'] = np.random.rand(len(df))
df['index_as_col'] = df.index
df1[['b','c']] = df2[['e','f']]
df3 = df1.append(other=df2)
```

Trap: When adding an indexed pandas object as a new column, only items from the new series that have a corresponding index in the DataFrame will be added. The receiving DataFrame is not extended to accommodate the new series. To merge, see below.
Trap: when adding a python list or numpy array, the column will be added by integer position.

Swap column contents – change column order

```
df[['B', 'A']] = df[['A', 'B']]
```

Dropping columns (mostly by label)

```
df = df.drop('col1', axis=1)
df.drop('col1', axis=1, inplace=True)
df = df.drop(['col1','col2'], axis=1)
s = df.pop('col') # drops from frame
del df['col'] # even classic python works
df.drop(df.columns[0], inplace=True)
```

Vectorised arithmetic on columns

```
df['proportion']=df['count']/df['total']
df['percent'] = df['proportion'] * 100.0
```

Apply numpy mathematical functions to columns

```
df['log_data'] = np.log(df['col1'])
df['rounded'] = np.round(df['col2'], 2)
```

Note: Many more mathematical functions

Columns value set based on criteria

```
df['b']=df['a'].where(df['a']>0,other=0)
df['d']=df['a'].where(df.b!=0,other=df.c)
```

Note: where other can be a Series or a scalar

Data type conversions

```
s =   df['col'].astype(str) # Series dtype
na = df['col'].values             # numpy array
pl = df['col'].tolist()           # python list
```

Note: useful dtypes for Series conversion: int, float, str
Trap: index lost in conversion from Series to array or list

Common column-wide methods/attributes

```
value = df['col'].dtype        # type of data
value = df['col'].size         # col dimensions
value = df['col'].count()# non-NA count
value = df['col'].sum() value = df['col'].prod()
value = df['col'].min() value = df['col'].max()
value = df['col'].mean() value =
df['col'].median()          value =
df['col'].cov(df['col2'])


s = s     df['col'].describe()
=         df['col'].value_counts()
```

Find index label for min/max values in column

```
label   = df['col1'].idxmin()
label =    df['col1'].idxmax()
```

Common column element-wise methods

```
s = df['col'].isnull()
s = df['col'].notnull() # not isnull()
s = df['col'].astype(float)
s = df['col'].round(decimals=0)
s = df['col'].diff(periods=1)
s = df['col'].shift(periods=1)
s = df['col'].to_datetime()
s = df['col'].fillna(0) # replace NaN w 0
s = df['col'].cumsum()
s = df['col'].cumprod()
s = df['col'].pct_change(periods=4)
s = df['col'].rolling_sum(periods=4,

                                window=4)
```

Note: also rolling_min(), rolling_max(), and many more.

Append a column of row sums to a DataFrame

```
df['Total'] = df.sum(axis=1)
```

Note: also means, mins, maxs, etc.

Multiply every column in DataFrame by Series

```
df = df.mul(s, axis=0) # on matched rows
```

Note: also add, sub, div, etc.

Selecting columns with .loc, .iloc and .ix

```
df = df.loc[:, 'col1':'col2'] # inclusive
df = df.iloc[:, 0:2]          # exclusive
```

Get the integer position of a column index label

```
j = df.columns.get_loc('col_name')
```

Test if column index values are unique/monotonic

```
if df.columns.is_unique: pass # ... b =
df.columns.is_monotonic_increasing   b   =
df.columns.is_monotonic_decreasing
```

Working with rows

Get the row index and labels

```
idx = df.index # get row index label =
df.index[0] # 1st row label lst = df.index.tolist()
# get as a list
```

Change the (row) index

```
df.index = idx
# new ad hoc index
df.index = range(len(df)) # set with list
df = df.reset_index() # replace old w new
# note: old index stored as a col in df
df = df.reindex(index=range(len(df)))
df = df.set_index(keys=['r1','r2','etc'])
df.rename(index={'old':'new'},
          inplace=True)
```

Adding rows

```
df = original_df.append(more_rows_in_df)
```

Hint: convert to a DataFrame and then append. Both DataFrames should have same column labels.

Dropping rows (by name)

```
df = df.drop('row_label')
df = df.drop(['row1','row2']) # multi-row
```

Boolean row selection by values in a column

```
df = df[df['col2'] >= 0.0]
df = df[(df['col3']>=1.0) |
                                  (df['col1']<0.0)]
df = df[df['col'].isin([1,2,5,7,11])]
df = df[~df['col'].isin([1,2,5,7,11])]
df = df[df['col'].str.contains('hello')]
```

Trap: bitwise "or", "and" “not” (ie. | & ~) co-opted to be Boolean operators on a Series of Boolean

Trap: need parentheses around comparisons.

Selecting rows using isin over multiple columns

```
# fake up some data
data = {1:[1,2,3], 2:[1,4,9], 3:[1,8,27]}
df = pd.DataFrame(data)

# multi-column isin
lf = {1:[1, 3], 3:[8, 27]} # look for
f = df[df[list(lf)].isin(lf).all(axis=1)]
```

Selecting rows using an index

```
idx = df[df['col'] >= 2].index
print(df.ix[idx])
```

Select a slice of rows by integer position

[inclusive-from : exclusive-to [: step]]
default start is 0; default end is len(df)

```
df = df[:] df =     # copy DataFrame # rows
df[0:2]  df  =      0 and 1 # the last row #
df[-1:]  df  =      row 2 (the third row) # all
df[2:3]  df  =      but the last row # every
df[:-1]  df  =      2nd row (0 2 ..)
df[::2]
```

Trap: a single integer without a colon is a column label for integer numbered columns.

Select a slice of rows by label/index
[inclusive-from : inclusive–to [: step]]

```
df = df['a':'c'] # rows 'a' through 'c'
```

Trap: doesn't work on integer labelled rows

Append a row of column totals to a DataFrame

```
# Option 1: use dictionary comprehension
sums = {col: df[col].sum() for col in df}
sums_df = DataFrame(sums,index=['Total']) df
= df.append(sums_df)

# Option 2: All done with pandas
df = df.append(DataFrame(df.sum(),
                         columns=['Total']).T)
```

Iterating over DataFrame rows

```
for (index, row) in df.iterrows(): # pass
```

Trap: row data type may be coerced.

Sorting DataFrame rows values

```
df = df.sort(df.columns[0],
                          ascending=False)
df.sort(['col1', 'col2'], inplace=True)
```

Random selection of rows

```
import random as r
k = 20 # pick a number
selection = r.sample(range(len(df)), k)
df_sample = df.iloc[selection, :]
```

Note: this sample is not sorted

Sort DataFrame by its row index

```
df.sort_index(inplace=True) # sort by row
df = df.sort_index(ascending=False)
```

Drop duplicates in the row index

```
df['index'] = df.index # 1 create new col
df = df.drop_duplicates(cols='index',
            take_last=True)# 2 use new col
del df['index']             # 3 del the col
    df.sort_index(inplace=True)# 4 tidy up
```

Test if two DataFrames have same row index

```
len(a)==len(b) and all(a.index==b.index)
```

Get the integer position of a row or col index label

```
i = df.index.get_loc('row_label')
```

Trap: index.get_loc() returns an integer for a unique match. If not a unique match, may return a slice or mask.

Get integer position of rows that meet condition

```
a = np.where(df['col'] >= 2) #numpy array
```

Test if the row index values are unique/monotonic

```
if df.index.is_unique: pass # ... b =
df.index.is_monotonic_increasing b =
df.index.is_monotonic_decreasing
```

Working with cells

Selecting a cell by row and column labels

```
value = df.at['row', 'col']
value = df.loc['row', 'col']
value = df['col'].at['row']          # tricky
```

Note: .at[] fastest label based scalar lookup

Setting a cell by row and column labels

```
df.at['row', 'col'] = value
df.loc['row', 'col'] = value
df['col'].at['row'] = value          # tricky
```

Selecting and slicing on labels

```
df = df.loc['row1':'row3', 'col1':'col3']
```

Note: the "to" on this slice is inclusive.

Setting a cross-section by labels

```
df.loc['A':'C', 'col1':'col3'] = np.nan
df.loc[1:2,'col1':'col2']=np.zeros((2,2))
df.loc[1:2,'A':'C']=othr.loc[1:2,'A':'C']
```

Remember: inclusive "to" in the slice

Selecting a cell by integer position

```
value = df.iat[9, 3]                  # [row, col]
value = df.iloc[0, 0]                 # [row, col]
value = df.iloc[len(df)-1,
                len(df.columns)-1]
```

Selecting a range of cells by int position

```
df = df.iloc[2:4, 2:4] # subset of the df
df = df.iloc[:5, :5]        # top left corner
s = df.iloc[5, :] # returns row as Series
df = df.iloc[5:6, :] # returns row as row
```

Note: exclusive "to" – same as python list slicing.

Setting cell by integer position

```
df.iloc[0, 0] = value
df.iat[7, 8] = value                  # [row, col]
```

Setting cell range by integer position

```
df.iloc[0:3, 0:5] = value
df.iloc[1:3, 1:4] = np.ones((2, 3))
df.iloc[1:3, 1:4] = np.zeros((2, 3))
df.iloc[1:3, 1:4] = np.array([[1, 1, 1],
                              [2, 2, 2]])
```

Remember: exclusive-to in the slice

.ix for mixed label and integer position indexing

```
value = df.ix[5, 'col1']
df = df.ix[1:5, 'col1':'col3']
```

Views and copies

From the manual: Setting a copy can cause subtle errors. The rules about when a view on the data is returned are dependent on NumPy. Whenever an array of labels or a Boolean vector are involved in the indexing operation, the result will be a copy.

In summary: indexes and addresses

In the main, these notes focus on the simple, single level Indexes. Pandas also has a hierarchical or multi-level Indexes (aka the MultiIndex).

A DataFrame has two Indexes:

- Typically, the column index (df.columns) is a list of strings (observed variable names) or (less commonly) integers (the default is numbered from 0 to length-1)
- Typically, the row index (df.index) might be:
  - Integers - for case or row numbers (default is numbered from 0 to length-1);
  - Strings – for case names; or
  - DatetimeIndex or PeriodIndex – for time series data (more below)

Indexing

```
# --- selecting columns
s = df['col_label']             # scalar
df = df[['col_label']]          # one item list
df = df[['L1', 'L2']]           # many item list
df = df[index]                  # pandas Index
df = df[s]                      # pandas Series

# --- selecting rows
df = df['from':'inc_to']# label slice
df = df[3:7]                    # integer slice
df = df[df['col'] > 0.5]# Boolean Series

df = df.loc['label']            # single label
df = df.loc[container]          # lab list/Series
df = df.loc['from':'to']# inclusive slice

df = df.loc[bs]                 # Boolean Series
df = df.iloc[0]                 # single integer
df = df.iloc[container] # int list/Series
df = df.iloc[0:5]               # exclusive slice
df = df.ix[x]                   # loc then iloc

# --- select DataFrame cross-section
# r and c can be scalar, list, slice
df.loc[r, c] # label accessor (row, col)
df.iloc[r, c]# integer accessor
df.ix[r, c]       # label access int fallback
df[c].iloc[r]# chained – also for .loc

# --- select cell
#       r and c must be label or integer
df.at[r, c]       # fast scalar label accessor
df.iat[r, c] # fast scalar int accessor
df[c].iat[r] # chained – also for .at

# --- indexing methods v
df = df.get_value(r,c)  # get by row, col
df = df.set_value(r,c,v)# set by row, col
df = df.xs(key, axis) # get cross-section
df = df.filter(items, like, regex, axis)
df = df.select(crit, axis)
```

Note: the indexing attributes (.loc, .iloc, .ix, .at .iat) can be used to get and set values in the DataFrame.
Note: the .loc, iloc and .ix indexing attributes can accept python slice objects. But .at and .iat do not.
Note: .loc can also accept Boolean Series arguments
Avoid: chaining in the form df[col_indexer][row_indexer]
Trap: label slices are inclusive, integer slices exclusive.

Joining/Combining DataFrames

Three ways to join two DataFrames:

- merge (a database/SQL-like join operation)
- concat (stack side by side or one on top of the other)
- combine_first (splice the two together, choosing values from one over the other)

Merge on indexes

```
df_new = pd.merge(left=df1, right=df2,
            how='outer', left_index=True,
            right_index=True)
```

How: 'left', 'right', 'outer', 'inner'

Note: outer=union/all; inner=intersection

Merge on columns

```
df_new = pd.merge(left=df1, right=df2,
            how='left', left_on='col1',
            right_on='col2')
```

Trap: When joining on columns, the indexes on the passed DataFrames are ignored.

Trap: many-to-many merges on a column can result in an explosion of associated data.

Join on indexes (another way of merging)

```
df_new = df1.join(other=df2, on='col1',
                  how='outer')
df_new = df1.join(other=df2,on=['a','b'],
                  how='outer')
```

Note: DataFrame.join() joins on indexes by default. DataFrame.merge() joins on common columns by default.

Simple concatenation is often the best

```
df=pd.concat([df1,df2],axis=0)#top/bottom
df = df1.append([df2, df3]) #top/bottom
df=pd.concat([df1,df2],axis=1)#left/right
```

Trap: Can end up with duplicate rows or cols

Note: concat has an ignore_index parameter

Combine_first

```
df = df1.combine_first(other=df2)

# multi-combine with python reduce()
df = reduce(lambda x, y:
        x.combine_first(y),
            [df1, df2, df3, df4, df5])
```

Uses the non-null values from df1. The index of the combined DataFrame will be the union of the indexes from df1 and df2.

Groupby: Split-Apply-Combine

The pandas "groupby" mechanism allows us to split the data into groups, apply a function to each group independently and then combine the results.

Grouping

```
gb = df.groupby('cat') # by one columns
gb = df.groupby(['c1','c2']) # by 2 cols
gb = df.groupby(level=0) # multi-index gb
gb = df.groupby(level=['a','b']) # mi gb
print(gb.groups)
```

Note: groupby() returns a pandas groupby object

Note: the groupby object attribute .groups contains a dictionary mapping of the groups.

Trap: NaN values in the group key are automatically dropped – there will never be a NA group.

Iterating groups – usually not needed

```
for name, group in gb:
    print (name)
    print (group)
```

Selecting a group

```
dfa = df.groupby('cat').get_group('a')
dfb = df.groupby('cat').get_group('b')
```

Applying an aggregating function

```
# apply to a column ...
s = df.groupby('cat')['col1'].sum()
s = df.groupby('cat')['col1'].agg(np.sum)
# apply to the every column in DataFrame
s = df.groupby('cat').agg(np.sum)
df_summary = df.groupby('cat').describe()
df_row_1s = df.groupby('cat').head(1)
```

Note: aggregating functions reduce the dimension by one – they include: mean, sum, size, count, std, var, sem, describe, first, last, min, max

Applying multiple aggregating functions

```
gb = df.groupby('cat')

# apply multiple functions to one column
dfx = gb['col2'].agg([np.sum, np.mean])
# apply to multiple fns to multiple cols
dfy = gb.agg({
    'cat': np.count_nonzero,
    'col1': [np.sum, np.mean, np.std],
    'col2': [np.min, np.max]
})
```

Note: gb['col2'] above is shorthand for df.groupby('cat')['col2'], without the need for regrouping.

Transforming functions

```
# transform to group z-scores, which have
# a group mean of 0, and a std dev of 1.
zscore = lambda x: (x-x.mean())/x.std()
dfz = df.groupby('cat').transform(zscore)

# replace missing data with group mean
mean_r = lambda x: x.fillna(x.mean())
dfm = df.groupby('cat').transform(mean_r)
```

Note: can apply multiple transforming functions in a manner similar to multiple aggregating functions above,

Applying filtering functions

Filtering functions allow you to make selections based on whether each group meets specified criteria

```
# select groups with more than 10 members
eleven = lambda x: (len(x['col1']) >= 11) df11 =
df.groupby('cat').filter(eleven)
```

Group by a row index (non-hierarchical index)

```
df = df.set_index(keys='cat') s =
df.groupby(level=0)['col1'].sum() dfg =
df.groupby(level=0).sum()
```

Pivot Tables

Pivot

Pivot tables move from long format to wide format data

```
df = DataFrame(np.random.rand(100,1))
df.columns = ['data'] # rename col
df.index = pd.period_range('3/3/2014',

         periods=len(df), freq='M')
df['year'] = df.index.year
df['month'] = df.index.month

# pivot to wide format
df = df.pivot(index='year',
     columns='month', values='data')

# melt to long format
dfm = df
dfm['year'] = dfm.index
dfm = pd.melt(df, id_vars=['year'],
     var_name='month', value_name='data')

# unstack to long format # reset index to
remove multi-level index
dfu=df.unstack().reset_index(name='data')
```

Value counts

```
s = df['col1'].value_counts()
```

Working with dates, times and their indexes

Dates and time – points and spans

With its focus on time-series data, pandas has a suite of tools for managing dates and time: either as a point in time (a Timestamp) or as a span of time (a Period).

```
t = pd.Timestamp('2013-01-01')
t = pd.Timestamp('2013-01-01 21:15:06')
t = pd.Timestamp('2013-01-01 21:15:06.7')
p = pd.Period('2013-01-01', freq='M')
```

Note: Timestamps should be in range 1678 and 2261 years. (Check Timestamp.max and Timestamp.min).

A Series of Timestamps or Periods

```
ts = ['2015-04-01 13:17:27',
        '2014-04-02 13:17:29']

# Series of Timestamps (good)
s = pd.to_datetime(pd.Series(ts))

# Series of Periods (often not so good)
s = pd.Series( [pd.Period(x, freq='M')
        for x in ts] )
s = pd.Series(
        pd.PeriodIndex(ts,freq='S'))
```

Note: While Periods make a very useful index; they may be less useful in a Series.

From non-standard strings to Timestamps

```
t = ['09:08:55.7654-JAN092002',
        '15:42:02.6589-FEB082016']
s = pd.Series(pd.to_datetime(t,
        format="%H:%M:%S.%f-%b%d%Y"))
```

Also: %B = full month name; %m = numeric month; %y = year without century; and more …

Dates and time – stamps and spans as indexes

An index of Timestamps is a DatetimeIndex.
An index of Periods is a PeriodIndex.

```
date_strs = ['2014-01-01', '2014-04-01',
'2014-07-01', '2014-10-01']


dti = pd.DatetimeIndex(date_strs)

pid = pd.PeriodIndex(date_strs, freq='D') pim
= pd.PeriodIndex(date_strs, freq='M') piq =
pd.PeriodIndex(date_strs, freq='Q')

print (pid[1] - pid[0]) print # 90 days
(pim[1] - pim[0]) print # 3 months
(piq[1] - piq[0])        # 1 quarter

     time_strs = ['2015-01-01 02:10:40.12345',
             '2015-01-01 02:10:50.67890']
   pis = pd.PeriodIndex(time_strs, freq='U')

df.index = pd.period_range('2015-01',
        periods=len(df), freq='M')

dti = pd.to_datetime(['04-01-2012'],
  dayfirst=True) # Australian date format
pi = pd.period_range('1960-01-01',
  '2015-12-31', freq='M')
```

Hint: unless you are working in less than seconds, prefer PeriodIndex over DateTimeImdex.

Period frequency constants (not a complete list)

Name	Description
U	Microsecond Millisecond Second
L	Minute Hour Calendar day
S	Business day Week ending on ...
T	Calendar start of month Calendar
H	end of month Quarter start with
D	year starting
B	(QS – December)
W-{MON, TUE, ...}	Quarter end with year ending (Q – December)
MS	
M	Year start (AS - December)
QS-{JAN, FEB, ...}	Year end (A - December)
Q-{JAN, FEB, ...}	
AS-{JAN, FEB, ...}	
A-{JAN, FEB, ...}	

From DatetimeIndex to Python datetime objects

```
dti = pd.DatetimeIndex(pd.date_range(
    start='1/1/2011', periods=4, freq='M'))
s = Series([1,2,3,4], index=dti)
na = s.index.to_pydatetime()
#numpy array
```

Frome Timestamps to Python dates or times

```
df['date'] = [x.date() for x in df['TS']] df['time']
= [x.time() for x in df['TS']]
```

Note: converts to datatime.date or datetime.time. But does not convert to datetime.datetime.

From DatetimeIndex to PeriodIndex and back

```
df = DataFrame(np.random.randn(20,3))
df.index = pd.date_range('2015-01-01',
          periods=len(df), freq='M')
dfp = df.to_period(freq='M')
dft = dfp.to_timestamp()
```

Note: from period to timestamp defaults to the point in time at the start of the period.

Working with a PeriodIndex

```
pi = pd.period_range('1960-01','2015-12',
                         freq='M')
na = pi.values # numpy array of integers
lp = pi.tolist() # python list of Periods
sp = Series(pi)# pandas Series of Periods
ss = Series(pi).astype(str) # S of strs
ls = Series(pi).astype(str).tolist()
```

Get a range of Timestamps

```
dr = pd.date_range('2013-01-01',
      '2013-12-31', freq='D')
```

Error handling with dates

```
# 1st example returns string not Timestamp
t = pd.to_datetime('2014-02-30')
# 2nd example returns NaT (not a time)
t = pd.to_datetime('2014-02-30',
         coerce=True)
# NaT like NaN tests True for isnull()
b = pd.isnull(t) # --> True
```

The tail of a time-series DataFrame

```
df = df.last("5M") # the last five months
```

Upsampling and downsampling

```
# upsample from quarterly to monthly
pi = pd.period_range('1960Q1',
periods=220, freq='Q')
df = DataFrame(np.random.rand(len(pi),5),
         index=pi)
dfm = df.resample('M', convention='end') #
use ffill or bfill to fill with values

# downsample from monthly to quarterly
dfq = dfm.resample('Q', how='sum')
```

Time zones

```
t = ['2015-06-30 00:00:00',
      '2015-12-31 00:00:00']
dti = pd.to_datetime(t
      ).tz_localize('Australia/Canberra')
dti = dti.tz_convert('UTC')
ts = pd.Timestamp('now',
      tz='Europe/London')

# get a list of all time zones
import pyzt
for tz in pytz.all_timezones:
    print tz
```

Note: by default, Timestamps are created without time zone information.

Row selection with a time-series index

```
# start with the play data above idx =
pd.period_range('2015-01',
          periods=len(df), freq='M')
df.index = idx

february_selector = (df.index.month == 2)
february_data = df[february_selector]

q1_data = df[(df.index.month >= 1) &
    (df.index.month <= 3)]

mayornov_data = df[(df.index.month == 5)
    | (df.index.month == 11)]

totals = df.groupby(df.index.year).sum()
```

~~A~~ lso: year, month, day [of month], hour, minute, second, dayofweek [Mon=0 .. Sun=6], weekofmonth, weekofyear [numbered from 1], week starts on Monday], dayofyear [from 1], ...

The Series.dt accessor attribute

DataFrame columns that contain datetime-like objects can be manipulated with the .dt accessor attribute

```
t = ['2012-04-14 04:06:56.307000',
'2011-05-14 06:14:24.457000',
'2010-06-14 08:23:07.520000']

# a Series of time stamps
s = pd.Series(pd.to_datetime(t))
print(s.dtype)           # datetime64[ns]
print(s.dt.second)       # 56, 24,    7
print(s.dt.month)        #   4,   5,    6

# a Series of time periods
s = pd.Series(pd.PeriodIndex(t,freq='Q'))
print(s.dtype)           # datetime64[ns]
print(s.dt.quarter) #      2,    2,    2
print(s.dt.year)         # 2012, 2011, 2010
```

Working with missing and non-finite data

Working with missing data

Pandas uses the not-a-number construct (np.nan and float('nan')) to indicate missing data. The Python None can arise in data as well. It is also treated as missing data; as is the pandas not-a-time construct (pandas.NaT).

Missing data in a Series

```
s = Series( [8,None,float('nan'),np.nan])
            #[8,    NaN,   NaN,   NaN]
s.isnull() #[False, True,  True,  True]
s.notnull()#[True,  False, False, False]
s.fillna(0)#[8,     0,     0,     0]
```

Missing data in a DataFrame

```
df = df.dropna() # drop all rows with NaN df = df.dropna(axis=1) # same for cols
df=df.dropna(how='all') #drop all NaN row
df=df.dropna(thresh=2) # drop 2+ NaN in r # only drop row if NaN in a specified col df = df.dropna(df['col'].notnull())
```

Recoding missing data

```
df.fillna(0, inplace=True) # np.nan !! 0
s = df['col'].fillna(0)    # np.nan   0
df = df.replace(r'\s+', np.nan,
    regex=True) # white space ! np.nan
```

Non-finite numbers

With floating point numbers, pandas provides for positive and negative infinity.

```
s = Series([float('inf'), float('-inf'),
    np.inf, -np.inf])
```

Pandas treats integer comparisons with plus or minus infinity as expected.

Testing for finite numbers

(using the data from the previous example)

```
b = np.isfinite(s)
```

Working with Categorical Data

Categorical data

The pandas Series has an R factors-like data type for encoding categorical data.

```
s = Series(['a','b','a','c','b','d','a'],
    dtype='category')
df['B'] = df['A'].astype('category')
```

Note: the key here is to specify the "category" data type.
Note: categories will be ordered on creation if they are sortable. This can be turned off. See ordering below.

Convert back to the original data type

```
s = Series(['a','b','a','c','b','d','a'],
    dtype='category')
s = s.astype('string')
```

Ordering, reordering and sorting

```
s = Series(list('abc'), dtype='category')
print (s.cat.ordered)
s=s.cat.reorder_categories(['b','c','a'])
s = s.sort()
s.cat.ordered = False
```

Trap: category must be ordered for it to be sorted

Renaming categories

```
s = Series(list('abc'), dtype='category')
s.cat.categories = [1, 2, 3] # in place
s = s.cat.rename_categories([4,5,6])
# using a comprehension ...
s.cat.categories = ['Group ' + str(i)
    for i in s.cat.categories]
```

Trap: categories must be uniquely named

Adding new categories

```
s = s.cat.add_categories([4])
```

Removing categories

```
s = s.cat.remove_categories([4])
s.cat.remove_unused_categories() #inplace
```

Working with strings

Working with strings

```
# assume that df['col'] is series of strings s = df['col'].str.lower() s = df['col'].str.upper() s = df['col'].str.len()



# the next set work like Python
df['col'] += 'suffix'                # append
df['col'] *= 2                       # duplicate
s = df['col1'] + df['col2'] # concatenate
```

Most python string functions are replicated in the pandas DataFrame and Series objects.

Regular expressions

```
s = df['col'].str.contains('regex') s = df['col'].str.startswith('regex') s = df['col'].str.endswith('regex') s = df['col'].str.replace('old', 'new') df['b'] = df.a.str.extract('(pattern)')
```

Note: pandas has many more regex methods.

Basic Statistics

Summary statistics

```
s = df['col1'].describe()
df1 = df.describe()
```

DataFrame – key stats methods

```
df.corr()        # pairwise correlation cols # pairwise covariance cols # kurtosis over cols (def) # mean absolute deviation # standard error of mean # variance over cols (def)
df.cov()
df.kurt()
df.mad()
df.sem()
df.var()
```

Value counts

```
s = df['col1'].value_counts()
```

Cross-tabulation (frequency count)

```
ct = pd.crosstab(index=df['a'],
        cols=df['b'])
```

Quantiles and ranking

```
quants = [0.05, 0.25, 0.5, 0.75, 0.95]
q = df.quantile(quants)
r = df.rank()
```

Histogram binning

```
count, bins = np.histogram(df['col1'])
count, bins = np.histogram(df['col'],
bins=5)
count, bins = np.histogram(df['col1'],
               bins=[-3,-2,-1,0,1,2,3,4])
```

Regression

```
import statsmodels.formula.api as sm
result = sm.ols(formula="col1 ~ col2 +
           col3", data=df).fit()
print (result.params)
print (result.summary())
```

Smoothing example using rolling_apply

```
k3x5 = np.array([1,2,3,3,3,2,1]) / 15.0
s = pd.rolling_apply(df['col1'],
        window=7,
          func=lambda x: (x * k3x5).sum(),
           min_periods=7, center=True)
```

Cautionary note

This cheat sheet was cobbled together by bots roaming the dark recesses of the Internet seeking ursine and pythonic myths. There is no guarantee the narratives were captured and transcribed accurately. You use these notes at your own risk. You have been warned.