PANDAS FOUNDATIONS

Visual exploratory data analysis

The iris data set

- Famous data set in pattern recognition
- 150 observations, 4 features each
  - Sepal length
  - Sepal width
  - Petal length
  - Petal width
- 3 species: setosa, versicolor, virginica

Source: R.A. Fisher, Annual Eugenics, 7, Part II, 179-188 (1936), http://archive.ics.uci.edu/ml/datasets/Iris

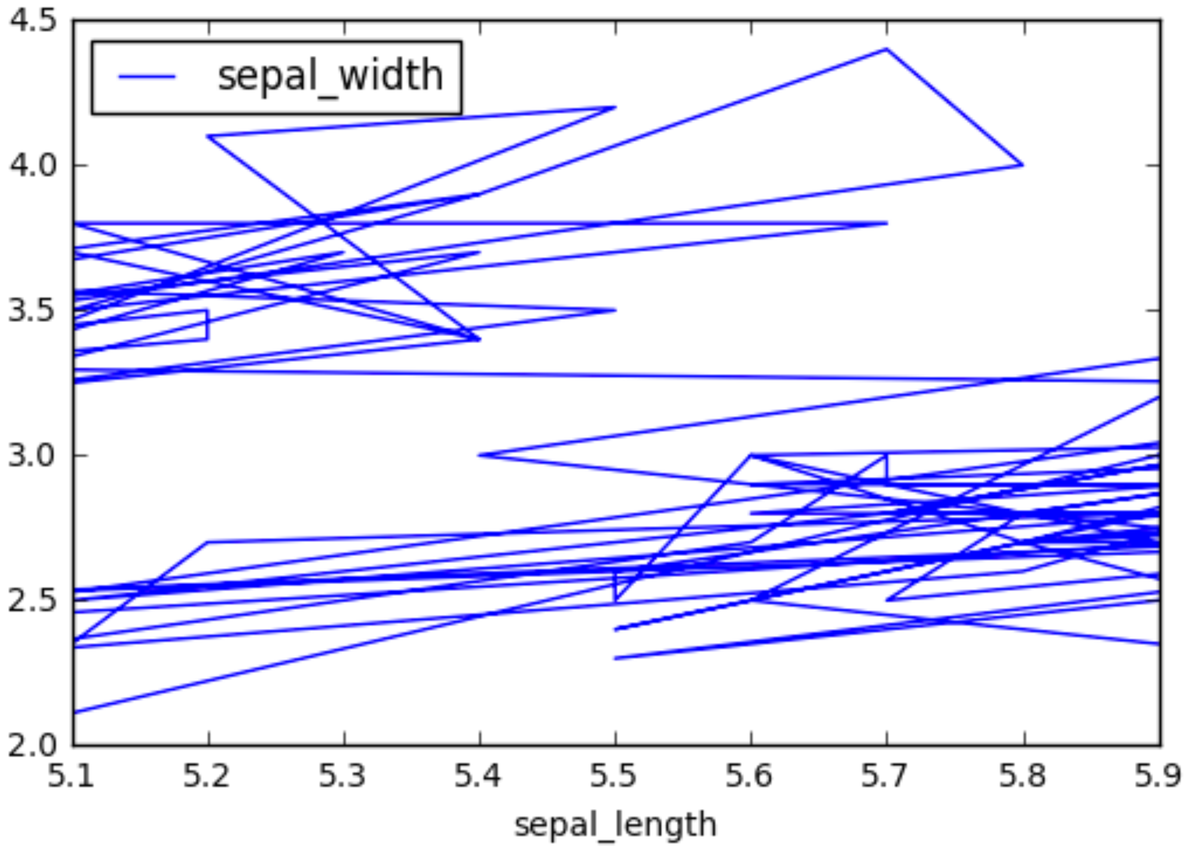
Data import

```
In [1]: import pandas as pd

In [2]: import matplotlib.pyplot as plt

In [3]: iris = pd.read_csv('iris.csv', index_col=0)

In [4]: print(iris.shape)
(150, 5)
```

Line plot

```
In [5]: iris.head()
Out[5]:
   sepal_length  sepal_width  petal_length  petal_width species
0           5.1          3.5           1.4          0.2  setosa
1           4.9          3.0           1.4          0.2  setosa
2           4.7          3.2           1.3          0.2  setosa
3           4.6          3.1           1.5          0.2  setosa
4           5.0          3.6           1.4          0.2  setosa

In [6]: iris.plot(x='sepal_length', y='sepal_width')

In [7]: plt.show()
```

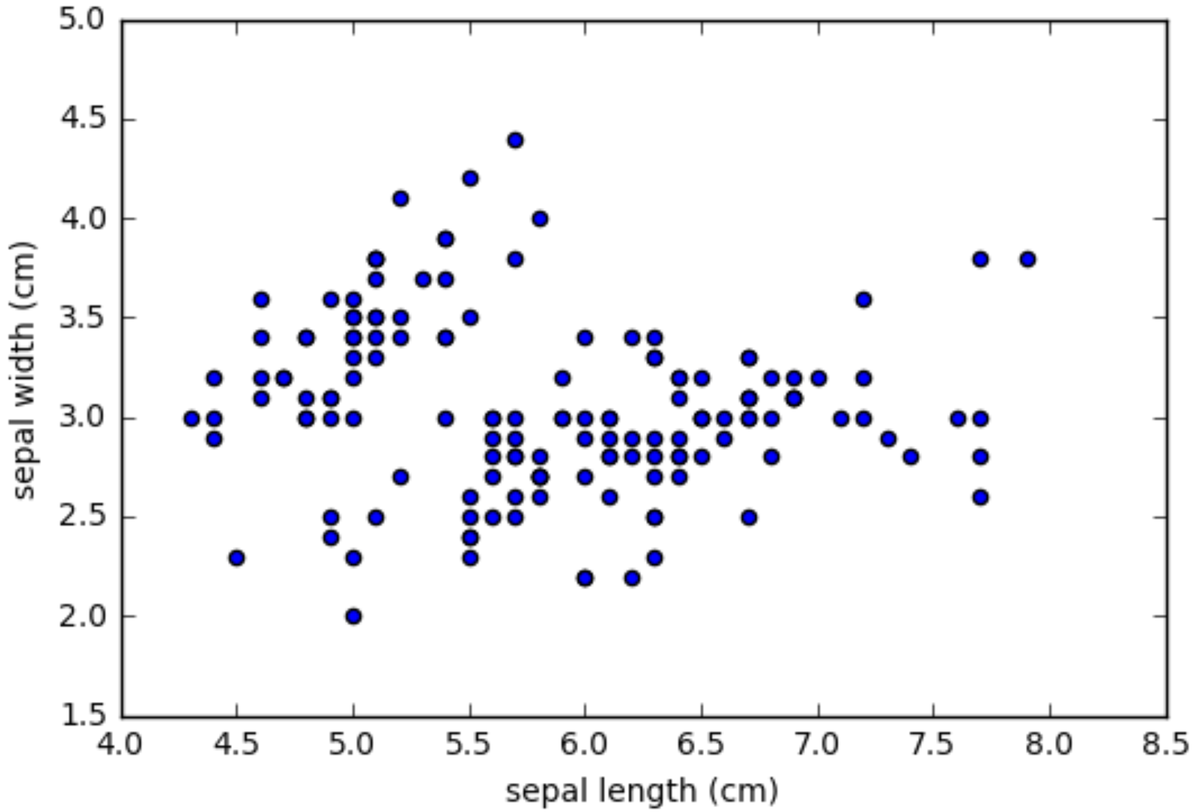
Line plot


sepal_width
4.5
4.0
3.5
3.0
2.5
2.0
5.1
5.2
5.3
5.4
5.5
5.6
5.7
5.8
5.9
sepal_length

Scatter plot

```
In [8]: iris.plot(x='sepal_length', y='sepal_width',
   ...:           kind='scatter')

In [9]: plt.xlabel('sepal length (cm)')

In [10]: plt.ylabel('sepal width (cm)')

In [11]: plt.show()
```

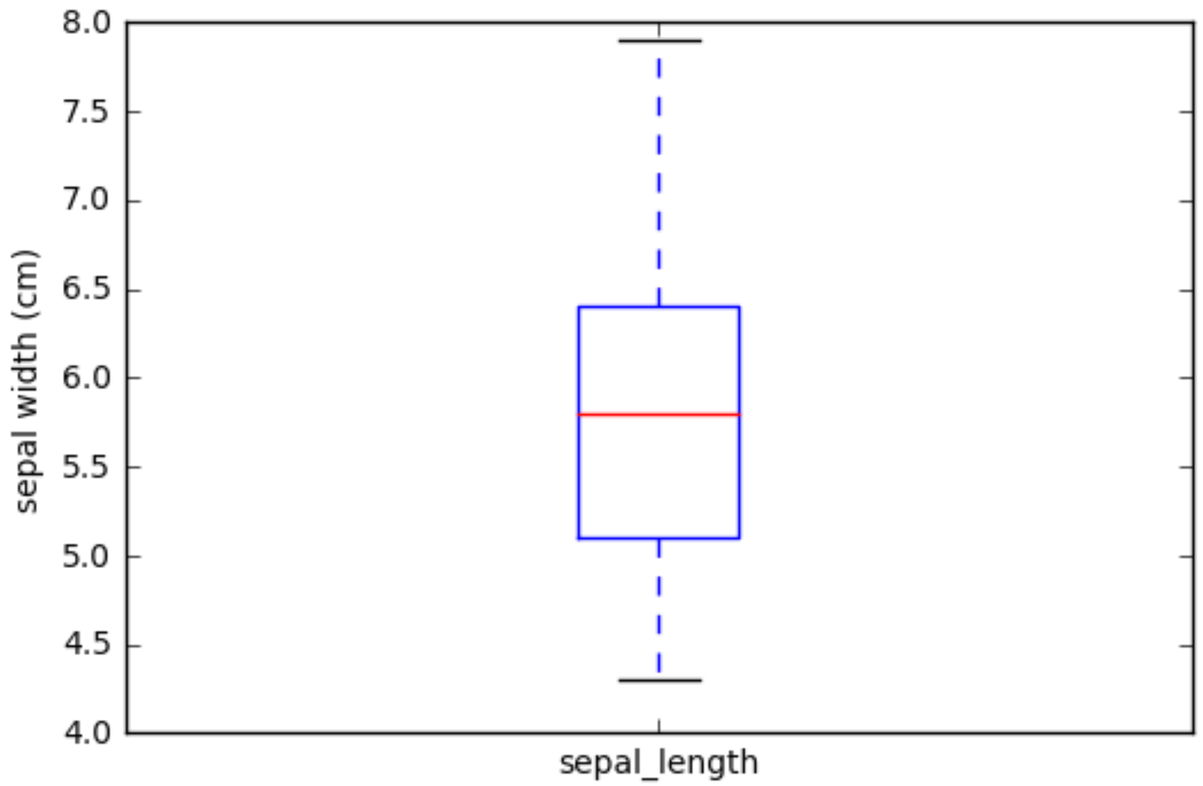
Scatter plot



Box plot

```
In [12]: iris.plot(y='sepal_length', kind='box')

In [13]: plt.ylabel('sepal width (cm)')

In [14]: plt.show()
```

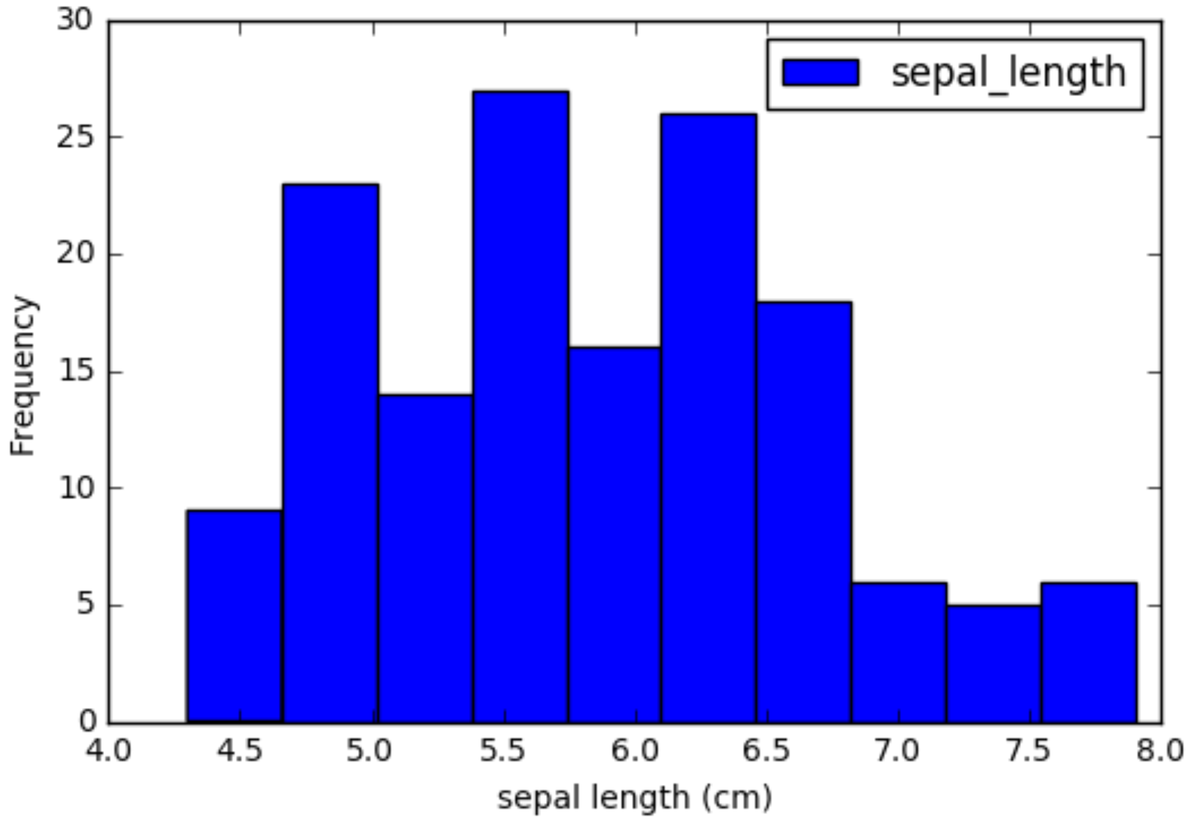
Box plot



Histogram

```
In [15]: iris.plot(y='sepal_length', kind='hist')

In [16]: plt.xlabel('sepal length (cm)')

In [17]: plt.show()
```

Histogram


sepal_length
Frequency
sepal length (cm)
0
5
10
15
20
25
30
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0

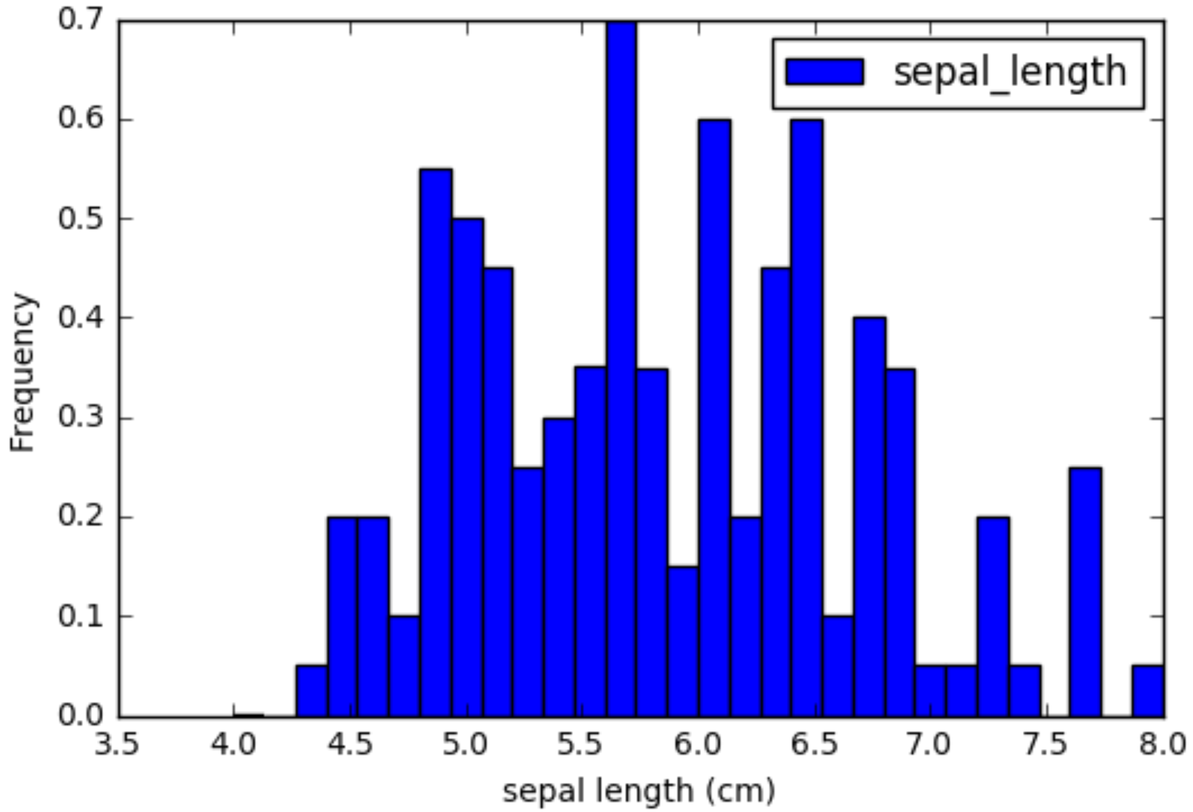
Histogram options

- *bins* (integer): number of intervals or bins
- *range* (tuple): extrema of bins (minimum, maximum)
- *normed* (boolean): whether to normalize to one
- *cumulative* (boolean): compute Cumulative Distribution Function (CDF)
- ... more Matplotlib customizations

Customizing histogram

```
In [18]: iris.plot(y='sepal_length', kind='hist',
    ...:           bins=30, range=(4,8), normed=True)

In [19]: plt.xlabel('sepal length (cm)')

In [20]: plt.show()
```

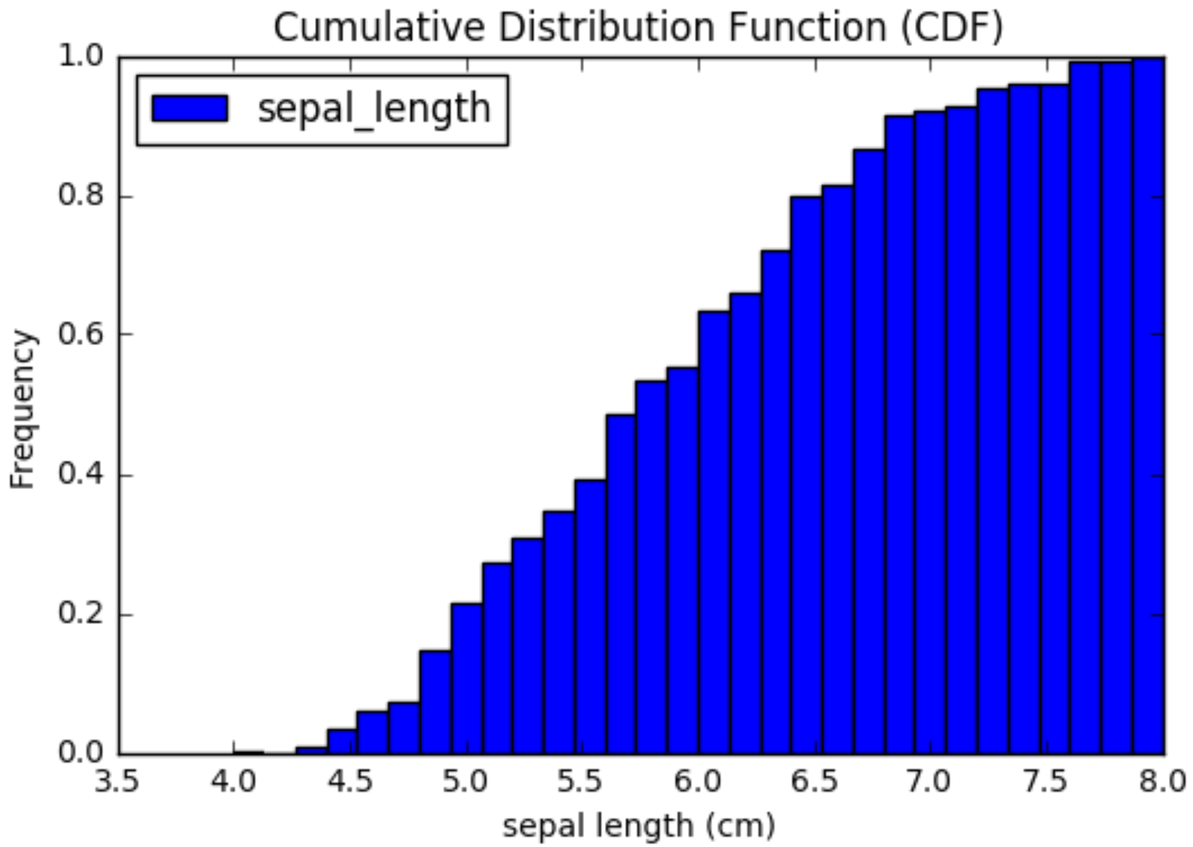
Customizing histogram



Cumulative distribution

```
In [21]: iris.plot(y='sepal_length', kind='hist', bins=30,
    ...:           range=(4,8), cumulative=True, normed=True)

In [22]: plt.xlabel('sepal length (cm)')

In [23]: plt.title('Cumulative distribution function (CDF)')

In [24]: plt.show()
```

Cumulative distribution



Word of warning

- Three different DataFrame plot idioms
  - *iris.plot(kind='hist')*
  - *iris.plt.hist()*
  - *iris.hist()*
- Syntax/results differ!
- Pandas API still evolving: check documentation!

PANDAS FOUNDATIONS

Let’s practice!

PANDAS FOUNDATIONS

Statistical exploratory data analysis

Summarizing with describe()

```
In [1]: iris.describe() # summary statistics
Out[1]:
        sepal_length  sepal_width  petal_length  petal_width
count     150.000000   150.000000    150.000000   150.000000
mean        5.843333     3.057333      3.758000     1.199333
std         0.828066     0.435866      1.765298     0.762238
min         4.300000     2.000000      1.000000     0.100000
25%         5.100000     2.800000      1.600000     0.300000
50%         5.800000     3.000000      4.350000     1.300000
75%         6.400000     3.300000      5.100000     1.800000
max         7.900000     4.400000      6.900000     2.500000
```

Describe

- *count*: number of entries
- *mean*: average of entries
- *std*: standard deviation
- min: minimum entry
- *25%*: first quartile
- *50%*: median or second quartile
- *75%*: third quartile
- *max*: maximum entry

Counts

```
In [2]: iris['sepal_length'].count() # Applied to Series
Out[2]: 150

In [3]: iris['sepal_width'].count() # Applied to Series
Out[3]: 150

In [4]: iris[['petal_length', 'petal_width']].count() # Applied
   ...: to DataFrame
Out[4]:
petal_length    150
petal_width     150
dtype: int64

In [5]: type(iris[['petal_length', 'petal_width']].count()) #
   ...: returns Series
Out[5]: pandas.core.series.Series
```

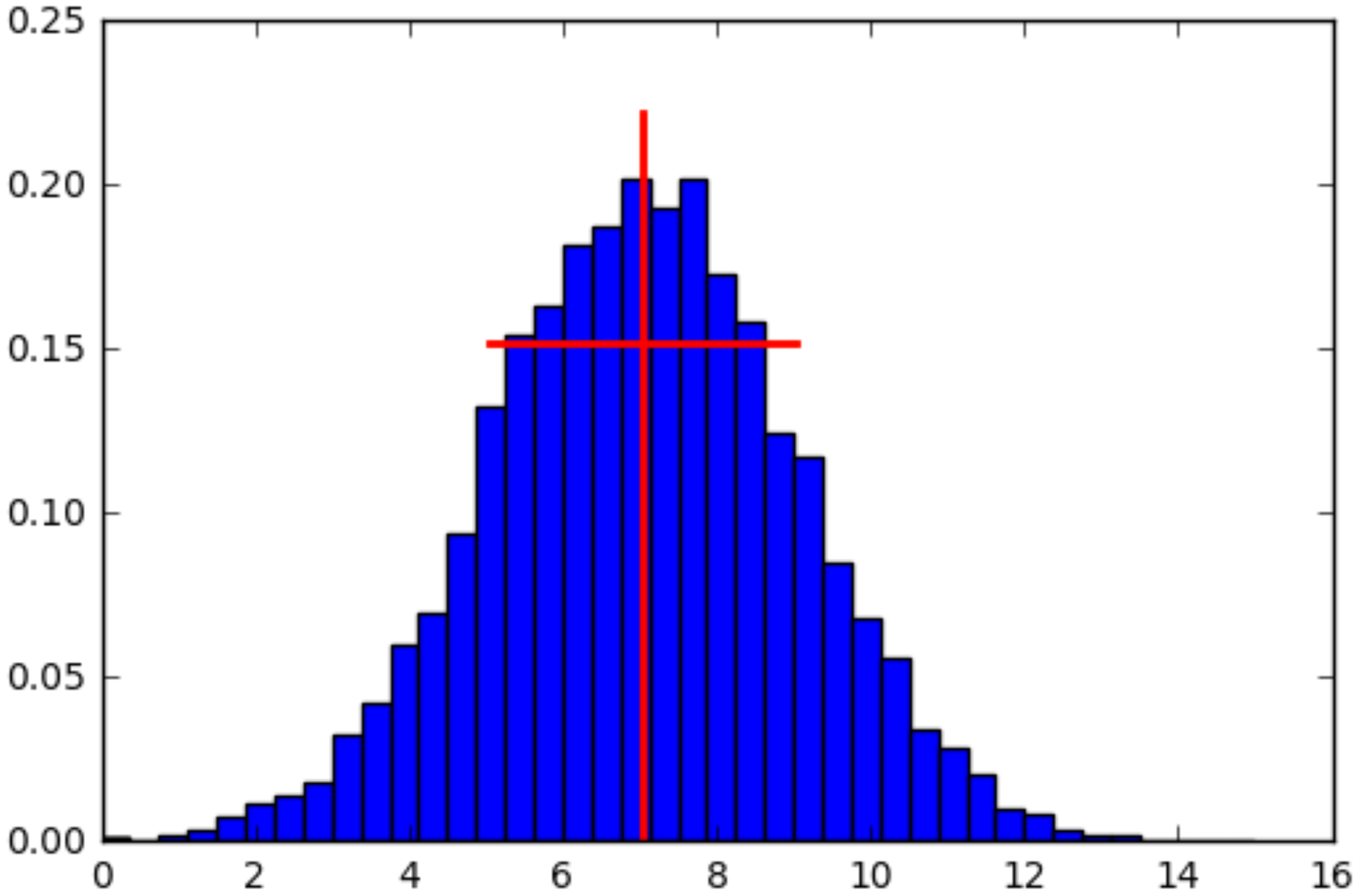
Averages

```
In [6]: iris['sepal_length'].mean() # Applied to Series
Out[6]: 5.843333333333335

In [7]: iris.mean() # Applied to entire DataFrame
Out[7]:
sepal_length    5.843333
sepal_width     3.057333
petal_length    3.758000
petal_width     1.199333
dtype: float64
```

Standard deviations

```
In [8]: iris.std()
Out[8]:
sepal_length    0.828066
sepal_width     0.435866
petal_length    1.765298
petal_width     0.762238
dtype: float64
```

Mean and standard deviation on a bell curve



Medians

```
In [9]: iris.median()
Out[9]:
sepal_length    5.80
sepal_width     3.00
petal_length    4.35
petal_width     1.30
dtype: float64
```

Medians & 0.5 quantiles

```
In [10]: iris.median()
Out[10]:
sepal_length    5.80
sepal_width     3.00
petal_length    4.35
petal_width     1.30
dtype: float64

In [11]: q = 0.5

In [12]: iris.quantile(q)
Out[12]:
sepal_length    5.80
sepal_width     3.00
petal_length    4.35
petal_width     1.30
dtype: float64
```

Inter-quartile range (IQR)

```
In [13]: q = [0.25, 0.75]

In [14]: iris.quantile(q)
Out[14]:
      sepal_length  sepal_width  petal_length  petal_width
0.25           5.1          2.8           1.6          0.3
0.75           6.4          3.3           5.1          1.8
```

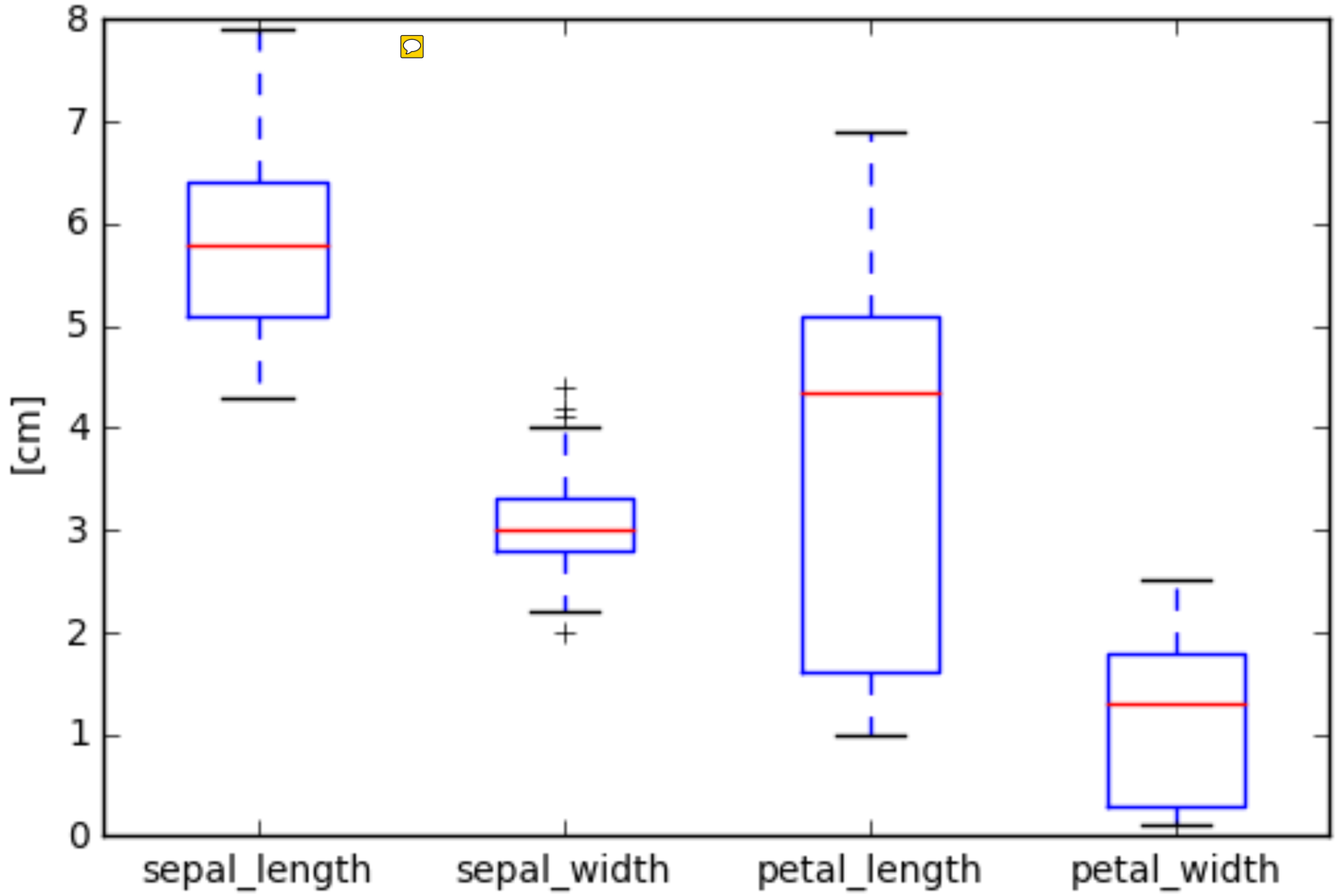
Ranges

```
In [15]: iris.min()
Out[15]:
sepal_length        4.3
sepal_width           2
petal_length          1
petal_width         0.1
species          setosa
dtype: object

In [16]: iris.max()
Out[16]:
sepal_length          7.9
sepal_width           4.4
petal_length          6.9
petal_width           2.5
species          virginica
dtype: object
```

Box plots

```
In [17]: iris.plot(kind= 'box')
Out[17]: <matplotlib.axes._subplots.AxesSubplot at 0x118a3d5f8>

In [18]: plt.ylabel('[cm]')
Out[18]: <matplotlib.text.Text at 0x118a524e0>

In [19]: plt.show()
```

Box plots


8
7
6
5
4
3
2
1
0
[cm]
sepal_length
sepal_width
petal_length
petal_width

Percentiles as quantiles

```
In [20]: iris.describe() # summary statistics
Out[20]:
       sepal_length  sepal_width  petal_length  petal_width
count    150.000000   150.000000    150.000000   150.000000
mean       5.843333     3.057333      3.758000     1.199333
std        0.828066     0.435866      1.765298     0.762238
min        4.300000     2.000000      1.000000     0.100000
25%        5.100000     2.800000      1.600000     0.300000
50%        5.800000     3.000000      4.350000     1.300000
75%        6.400000     3.300000      5.100000     1.800000
max        7.900000     4.400000      6.900000     2.500000
```

PANDAS FOUNDATIONS

Let’s practice!

PANDAS FOUNDATIONS

Separating populations

```
In [1]: iris.head()
Out[1]:
   sepal_length  sepal_width  petal_length  petal_width species
0           5.1          3.5           1.4          0.2  setosa
1           4.9          3.0           1.4          0.2  setosa
2           4.7          3.2           1.3          0.2  setosa
3           4.6          3.1           1.5          0.2  setosa
4           5.0          3.6           1.4          0.2  setosa
```

Describe species column

```
In [2]: iris['species'].describe()
Out[2]:
count         150
unique          3
top        setosa
freq           50
Name: species, dtype: object
```

count: # non-null entries
unique: # distinct values
top: most frequent category
freq: # occurrences of top

Unique & factors

```
In [3]: iris['species'].unique()
Out[3]: array(['setosa', 'versicolor', 'virginica'], dtype=object)
```

Filtering by species

```
In [4]: indices = iris['species'] == 'setosa'

In [5]: setosa = iris.loc[indices,:] # extract new DataFrame

In [6]: indices = iris['species'] == 'versicolor'

In [7]: versicolor = iris.loc[indices,:] # extract new DataFrame

In [8]: indices = iris['species'] == 'virginica'

In [9]: virginica = iris.loc[indices,:] # extract new DataFrame
```

Checking species

```
In [10]: setosa['species'].unique()
Out[10]: array(['setosa'], dtype=object)

In [11]: versicolor['species'].unique()
Out[11]: array(['versicolor'], dtype=object)

In [12]: virginica['species'].unique()
Out[12]: array(['virginica'], dtype=object)

In [13]: del setosa['species'], versicolor['species'],
    ...: virginica['species']
```

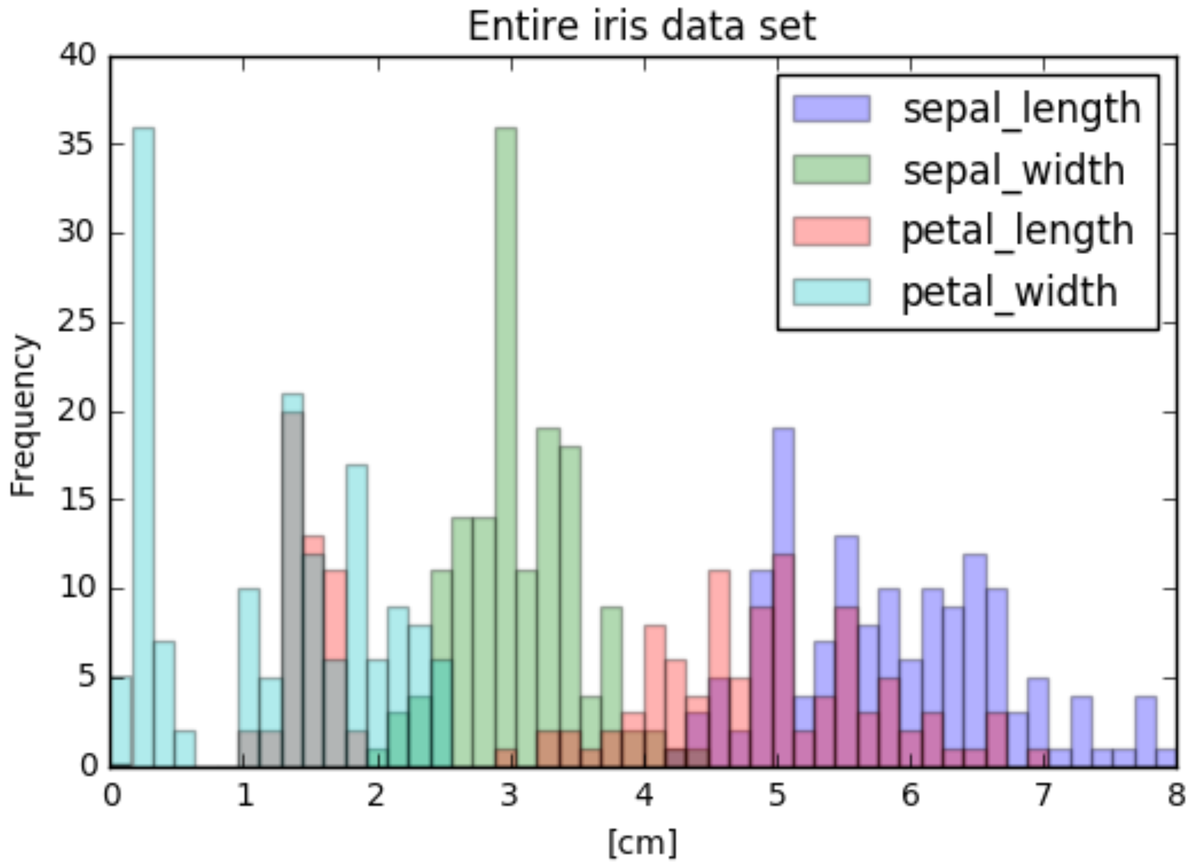
Checking indexes

```
In [14]: setosa.head(2)
Out[14]:
   sepal_length  sepal_width  petal_length  petal_width
0           5.1          3.5           1.4          0.2
1           4.9          3.0           1.4          0.2

In [15]: versicolor.head(2)
Out[15]:
    sepal_length  sepal_width  petal_length  petal_width
50           7.0          3.2           4.7          1.4
51           6.4          3.2           4.5          1.5

In [16]: virginica.head(2)
Out[16]:
     sepal_length  sepal_width  petal_length  petal_width
100           6.3          3.3           6.0          2.5
101           5.8          2.7           5.1          1.9
```

Visual EDA: all data

```
In [17]: iris.plot(kind= 'hist', bins=50, range=(0,8), alpha=0.3)

In [18]: plt.title('Entire iris data set')

In [19]: plt.xlabel('[cm]')

In [20]: plt.show()
```

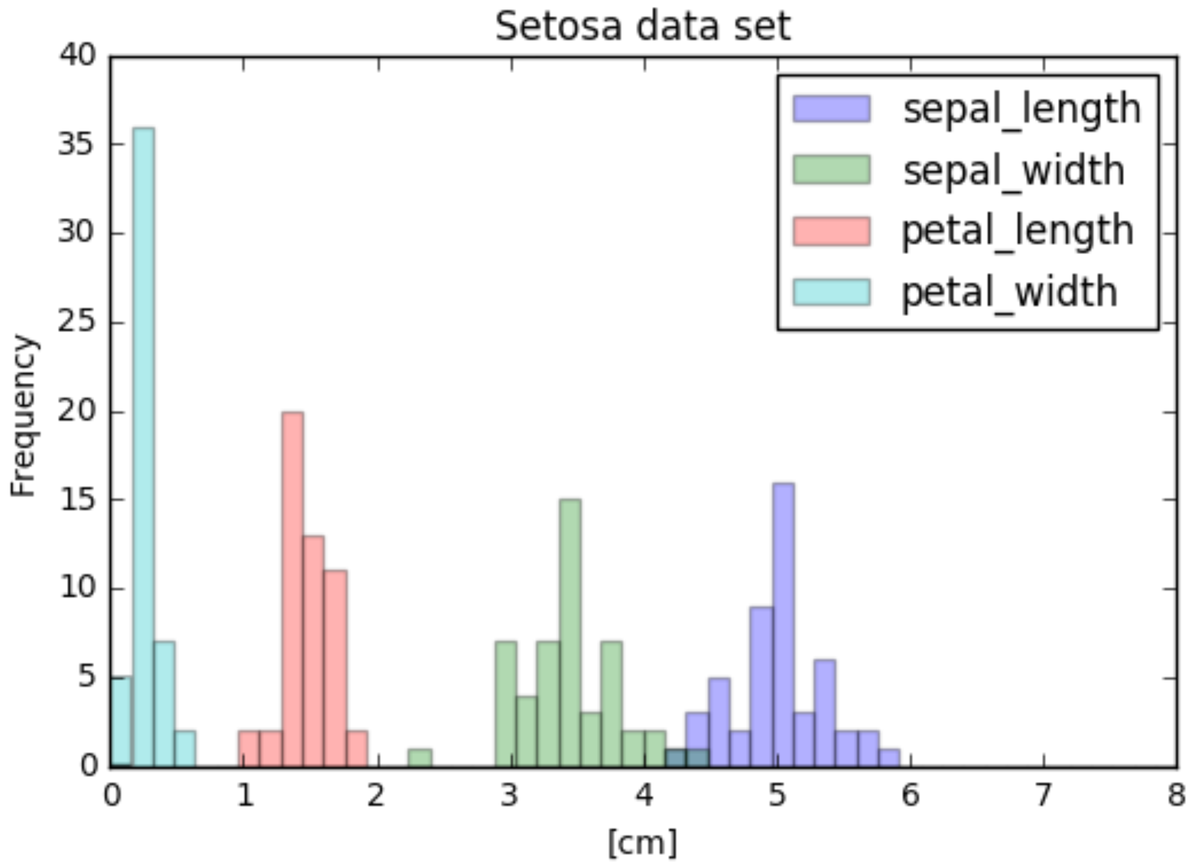
Visual EDA: all data



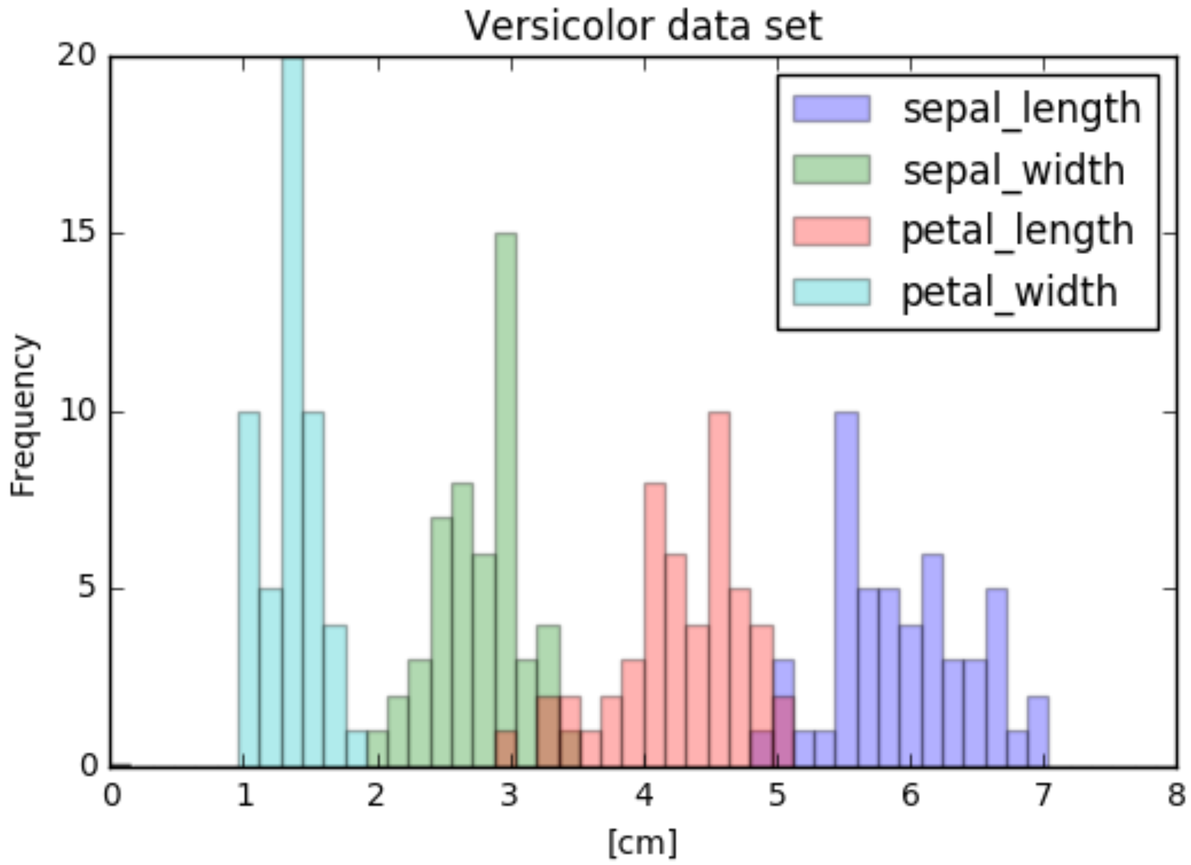
Visual EDA: individual factors

```
In [21]: setosa.plot(kind='hist', bins=50, range=(0,8), alpha=0.3)

In [22]: plt.title('Setosa data set’)

In [23]: plt.xlabel('[cm]')

In [24]: versicolor.plot(kind='hist', bins=50, range=(0,8), alpha=0.3)

In [25]: plt.title('Versicolor data set’)

In [26]: plt.xlabel('[cm]')

In [27]: virginica.plot(kind='hist', bins=50, range=(0,8), alpha=0.3)

In [28]: plt.title('Virginica data set’)

In [29]: plt.xlabel('[cm]')

In [30]: plt.show()
```

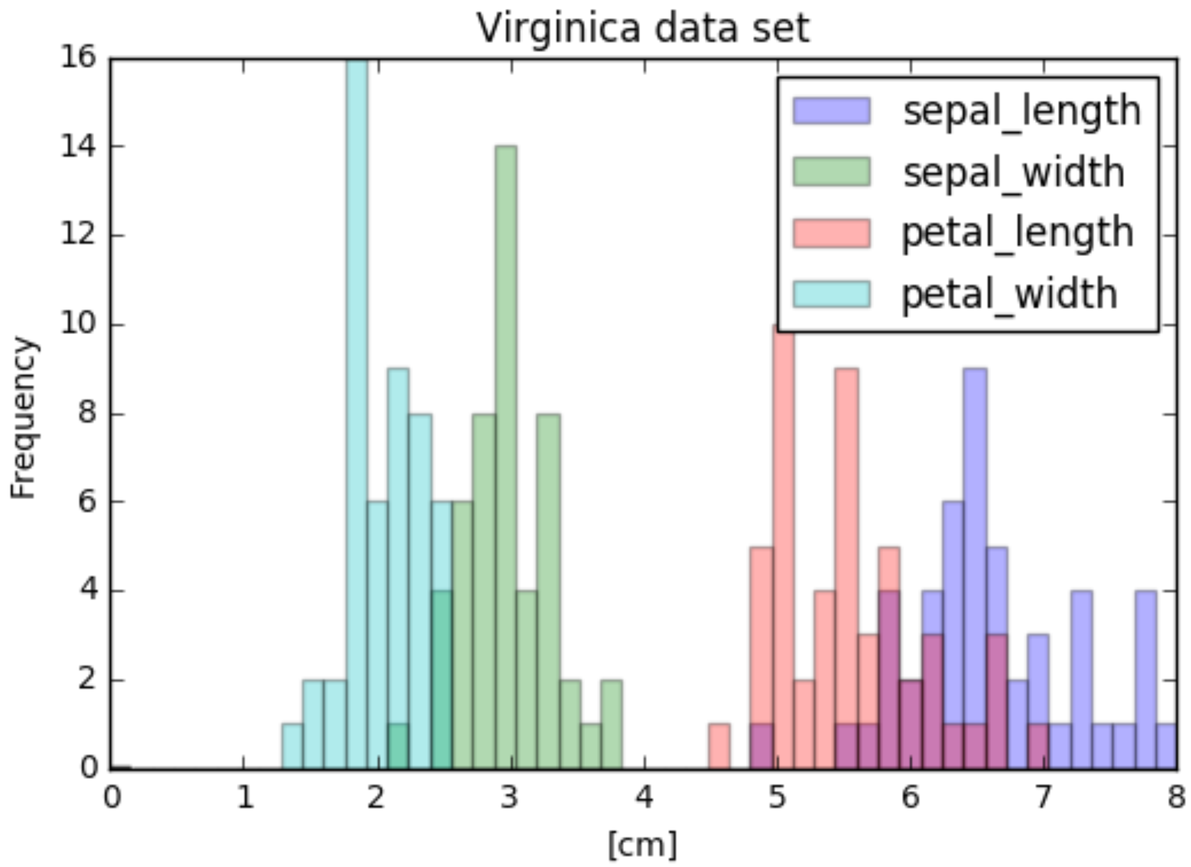
Visual EDA: Setosa data



Visual EDA: Versicolor data



Visual EDA: Virginica data



Statistical EDA: describe()

```
In [31]: describe_all = iris.describe()

In [32]: print(describe_all)
Out[32]:
       sepal_length  sepal_width  petal_length  petal_width
count    150.000000   150.000000    150.000000   150.000000
mean       5.843333     3.057333      3.758000     1.199333
std        0.828066     0.435866      1.765298     0.762238
min        4.300000     2.000000      1.000000     0.100000
25%        5.100000     2.800000      1.600000     0.300000
50%        5.800000     3.000000      4.350000     1.300000
75%        6.400000     3.300000      5.100000     1.800000
max        7.900000     4.400000      6.900000     2.500000

In [33]: describe_setosa = setosa.describe()

In [34]: describe_versicolor = versicolor.describe()

In [35]: describe_virginica = virginica.describe()
```

Computing errors

```
In [36]: error_setosa = 100 * np.abs(describe_setosa -
    ...: describe_all)

In [37]: error_setosa = error_setosa/describe_setosa

In [38]: error_versicolor = 100 * np.abs(describe_versicolor -
    ...: describe_all)

In [39]: error_versicolor = error_versicolor/describe_versicolor

In [40]: error_virginica = 100 * np.abs(describe_virginica -
    ...: describe_all)

In [41]: error_virginica = error_verginica/describe_virginica
```

Viewing errors

```
In [42]: print(error_setosa)
       sepal_length  sepal_width  petal_length  petal_width
count    200.000000   200.000000    200.000000   200.000000
mean      16.726595    10.812913    157.045144   387.533875
std      134.919250    14.984768    916.502136   623.284534
min        0.000000    13.043478      0.000000     0.000000
25%        6.250000    12.500000     14.285714    50.000000
50%       16.000000    11.764706    190.000000   550.000000
75%       23.076923    10.204082    223.809524   500.000000
max       36.206897     0.000000    263.157895   316.666667
```

PANDAS FOUNDATIONS

Let’s practice!