ML Summary and Next Steps in Illustrations

Data X: A Course on Data, Signals, and Systems

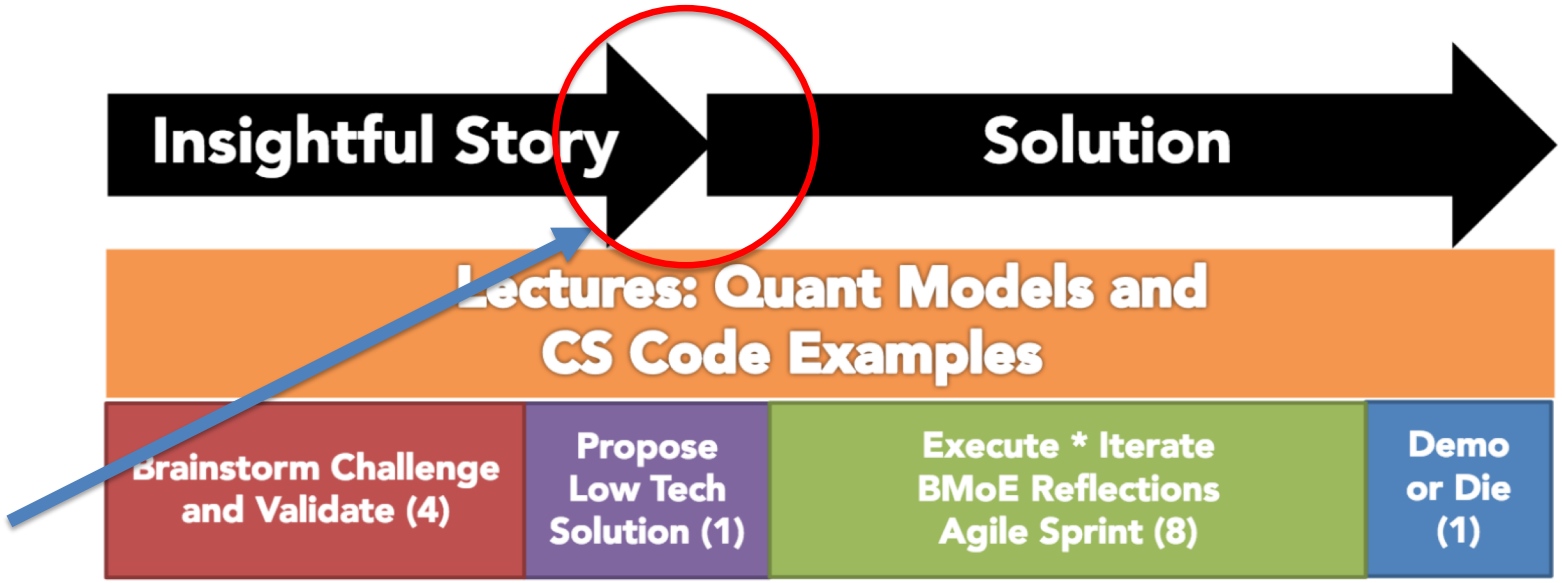
Ikhlaq Sidhu
Chief Scientist & Founding Director,
Sutardja Center for Entrepreneurship & Technology
IEOR Emerging Area Professor Award, UC Berkeley

Course Overview

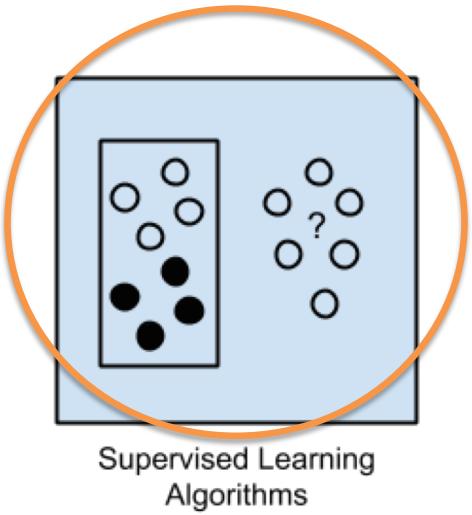
We are now here:

- tools
- theory

Titanic Notebook



Open-ended, real-world project: Typically 5 students, with available advisor network



X	Y
train	train
test	test
Non Labeled	Y?

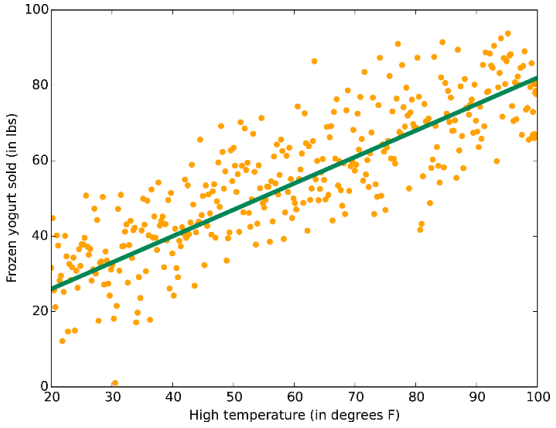
```
#Setting up for Supervised learning
# First clean: use mapping + buckets

# X = matrix of data – e.g 1000 rows
# Y = In sample responses

# Typically we want to split in to
training data and test data

X_train = X[0:500]
Y_train = Y[0:500]
X_test = X[501:1000]
Y_test = Y[501:1000]
```

Linear Regression Illustration



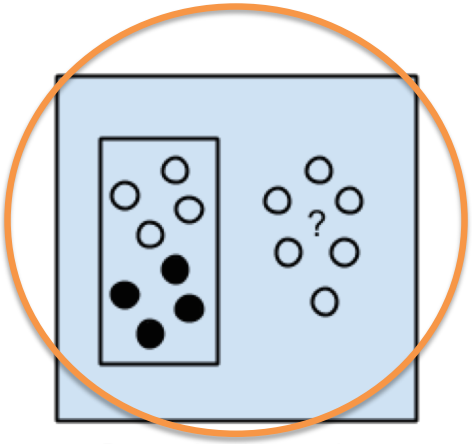

```
#Setting Linear Regression in sklearn
from sklearn import linear_model

model= linear_model.LinearRegression()
model.fit(X_train, Y_train)

Y_pred_train =  model.predict(X_train)
Y_pred_test =  model.predict(X_test)


# Compare Y_pred_test with Y_test for
error.
```

Illustration Source: https://docs.microsoft.com/en-us/azure/machine-learning/machine-learning-algorithm-choice



X	Y
train	train
test	test
Non Labeled	Y?

Common Issue:
Do you have enough data to train and then test?

Small training set -> ?
All training data -> ?

How to use the data efficiently?

```
#Setting up for Supervised learning
# First clean: use mapping + buckets

# X = matrix of data – e.g 1000 rows
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# Typically we want to split in to training data and test data

X_train = X[0:500]
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X_test = X[501:1000]
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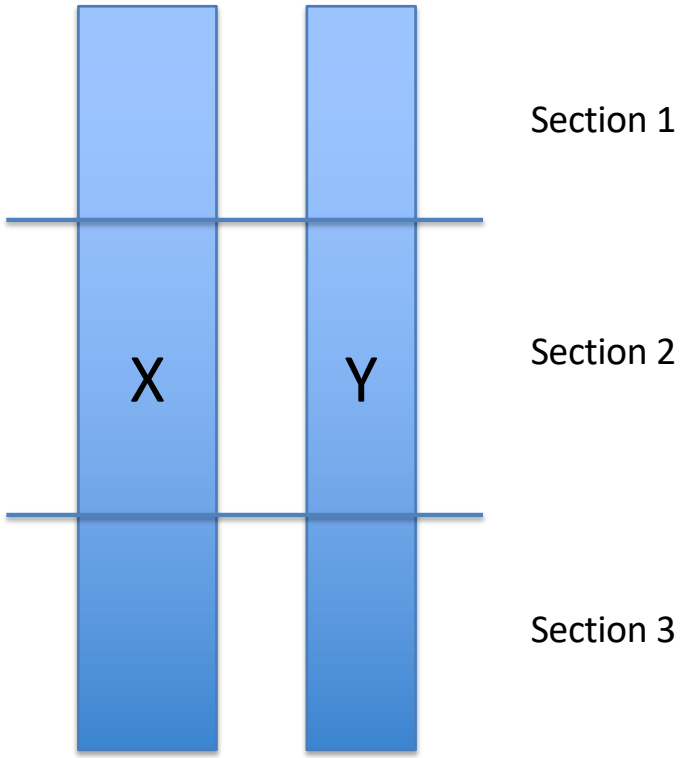
```

- Common Issue: Having enough data to train and test

- Cross Validation
- K-fold (ie 3-fold, 4-fold, ..

- Example:
  - Train (1,2) -> Test with 3
  - Train (2,3) -> Test with 1
  - Train (1,3(-> Test with 2
  - Estimate model error as average of all 3



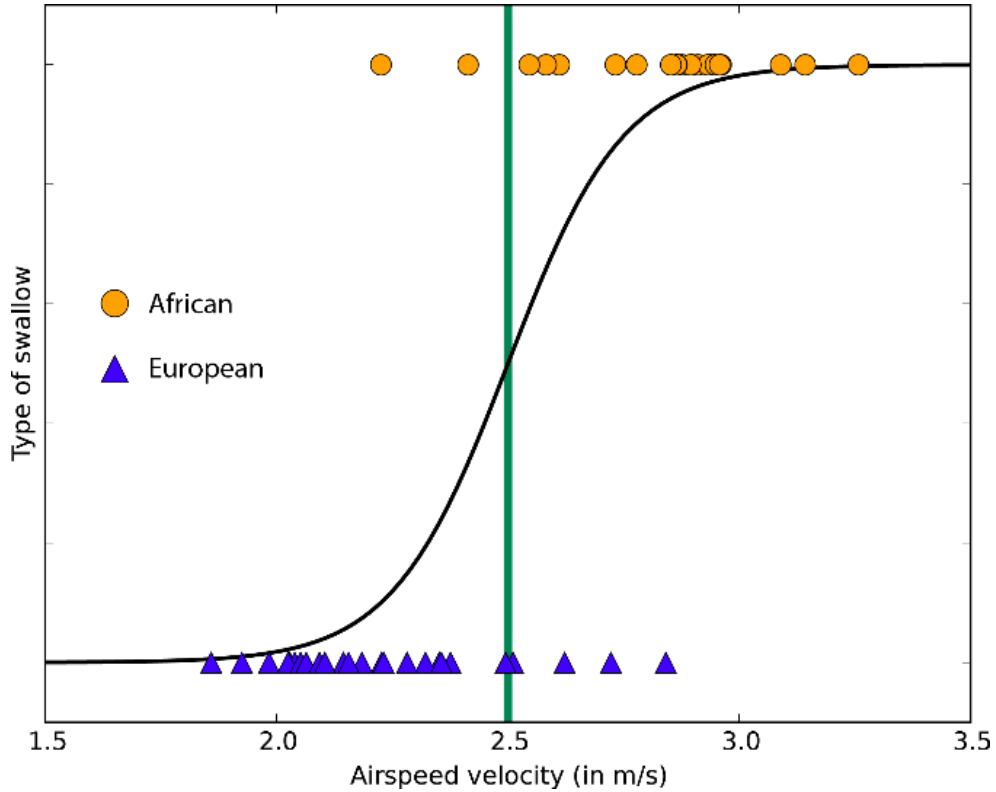
- Common issue: Having enough data to train and test
- Cross validation:
- k-fold (ie 3-fold, 4-fold, …
- Example:
  - Train (1,2) -> Test with 3
  - Train (2,3) -> Test with 1
  - Train (1,3(-> Test with 2
  - Estimate model error as average of all 3

The general procedure is as follows:

1. Shuffle the dataset randomly.
2. Split the dataset into k groups
3. For each unique group:
   1. Take the group as a hold out or test data set
   2. Take the remaining groups as a training data set
   3. Fit a model on the training set and evaluate it on the test set
   4. Retain the evaluation score and discard the model
4. Summarize the skill of the model using the sample of model evaluation scores

A Gentle Introduction to k-fold Cross-Validation by **Jason Brownlee**

Logistic Regression Illustration



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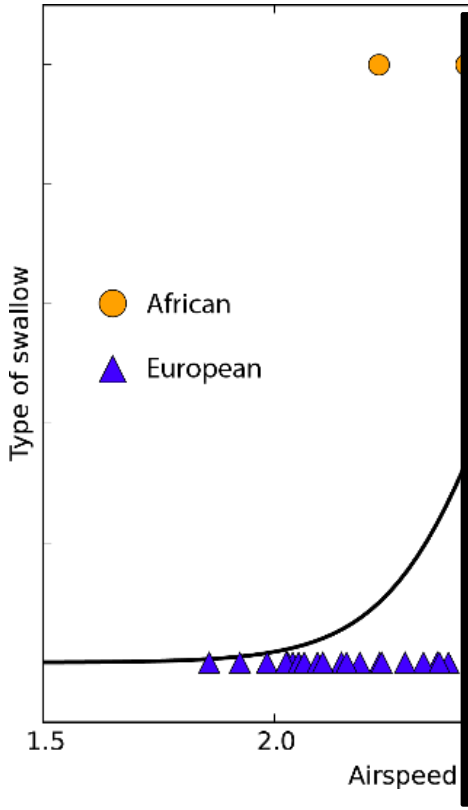
Logistic Regression Illustration




```
from sklearn.linear_model import LogisticRegression

# Logistic Regression
logreg = LogisticRegression()
logreg.fit(X_train, Y_train)          #option for weights
Y_pred = logreg.predict(X_test)       #no options

# Error
acc_log = round(logreg.score(X_train, Y_train) * 100, 2)
acc_log

# or compare Y_pred with Y_test
```

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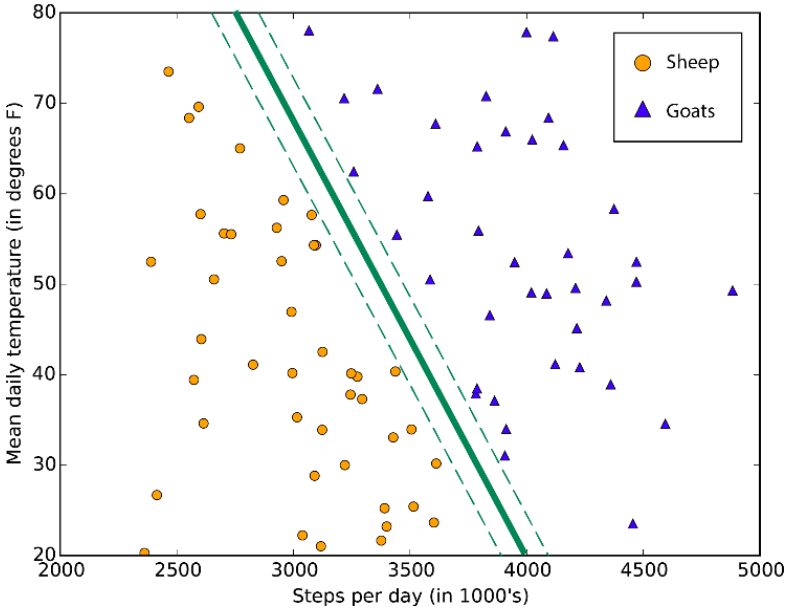
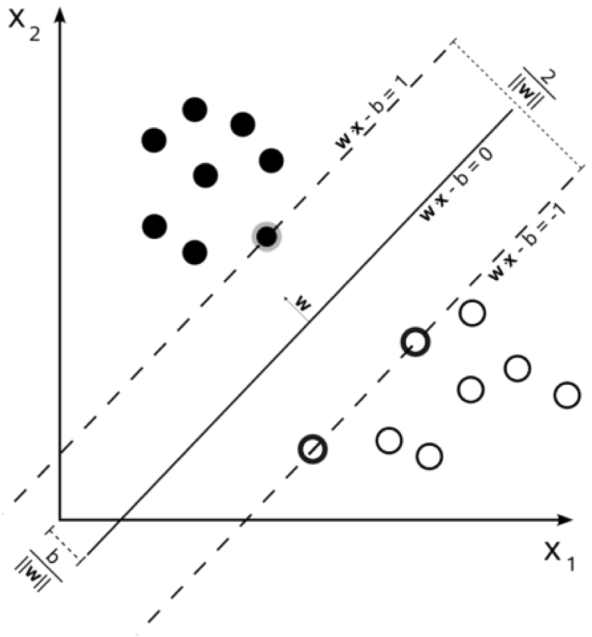
Support Vector Machine (SVM) Illustration



A typical support vector machine class boundary maximizes the margin separating two classes



$$\vec{w} \cdot \vec{x} - b = 0,$$

$$\vec{w} \cdot \vec{x} - b = 1$$

and

$$\vec{w} \cdot \vec{x} - b = -1.$$

$\frac{b}{\|\vec{w}\|}$ determines the offset

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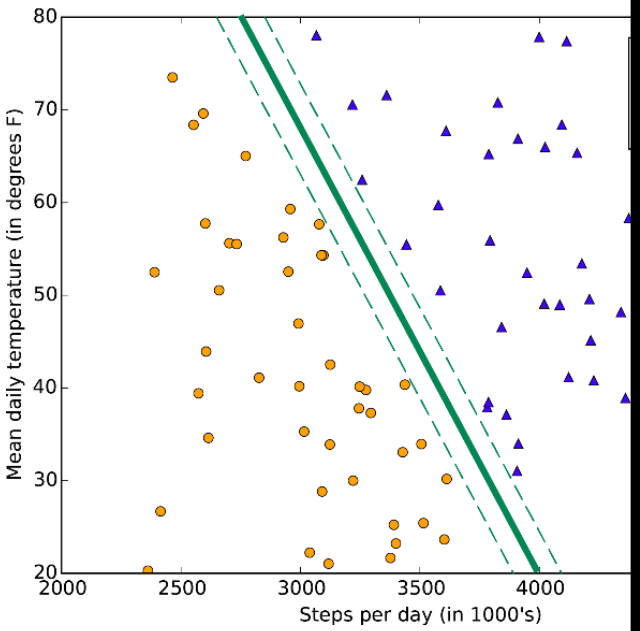
Support Vector Machine (SVM) Illustration



A typical support vector machine class boundary maximizes the margin s
classes

```
from sklearn.svm import SVC, LinearSVC

svc = SVC()
svc.fit(X_train, Y_train)
Y_pred = svc.predict(X_test)

# Error
acc_svc = round(svc.score(X_train, Y_train) * 100, 2)
acc_svc

# or compare Y_pred with Y_test
```

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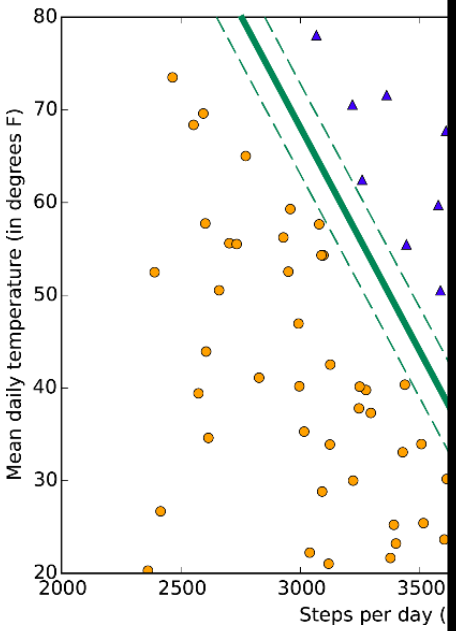

A typical support vector machine class boundary ma
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from sklearn.svm import SVC, LinearSVC

# Linear SVC
linear_svc = LinearSVC()
linear_svc.fit(X_train, Y_train)

Y_pred = linear_svc.predict(X_test)

# Error:
acc_linear_svc = round(linear_svc.score(X_train, Y_train) * 100, 2)
acc_linear_svc

# or compare Y_pred with Y_test
```

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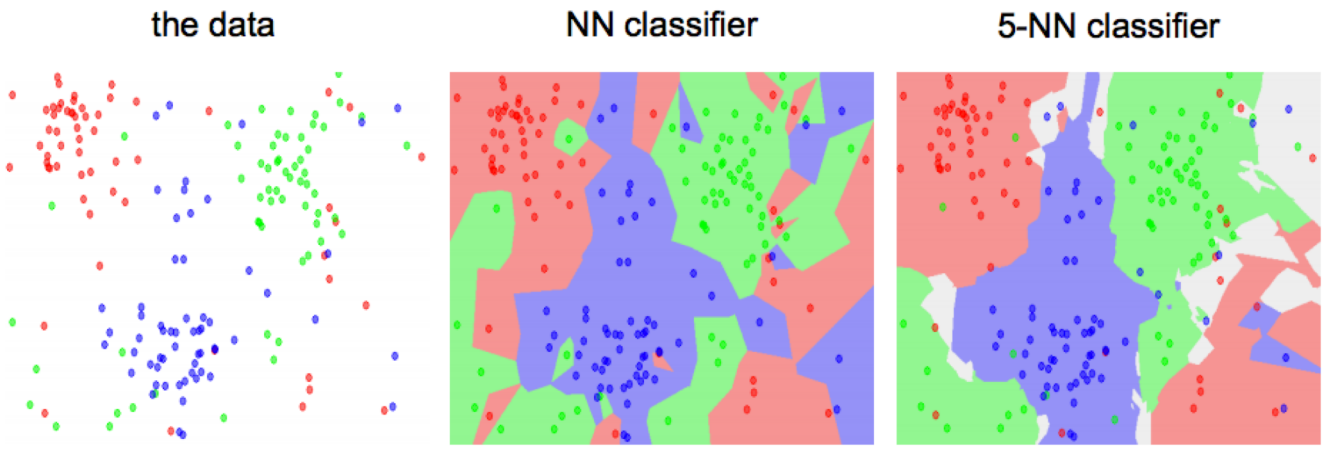
KNN Method: Find the k nearest images and have them vote on the label (i.e. take the mode)

KNN / K Means Illustration

Colour		Water	Rock
Red		109	24
Green		112	14
Blue		105	13
Red		137	15
Green		164	11
Blue		125	1
Red		179	24
		209	20
		177	13
?		136	17
		119	7
		107	0



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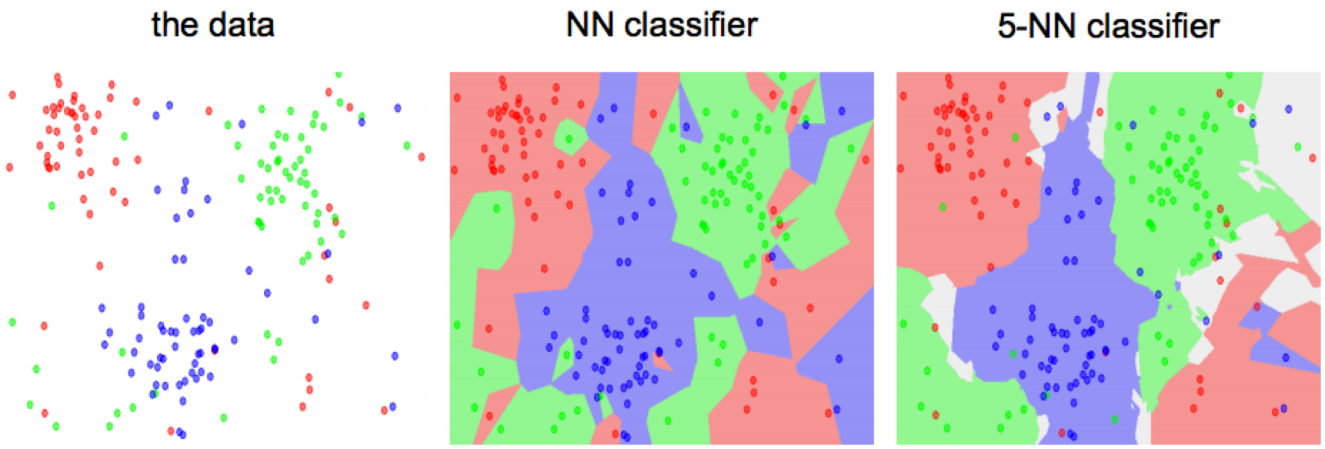

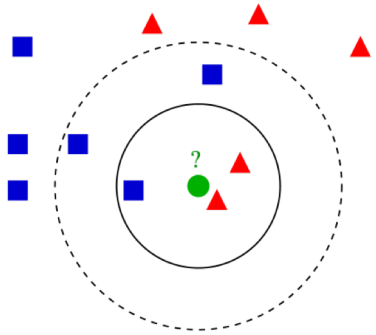

Example of *k*-NN classification. The test sample (green circle) should be classified either to the first class of blue squares or to the second class of red triangles. If *k = 3* (solid line circle) it is assigned to the second class because there are 2 triangles and only 1 square inside the inner circle. If *k = 5* (dashed line circle) it is assigned to the first class (3 squares vs. 2 triangles inside the outer circle). - Wikipedia

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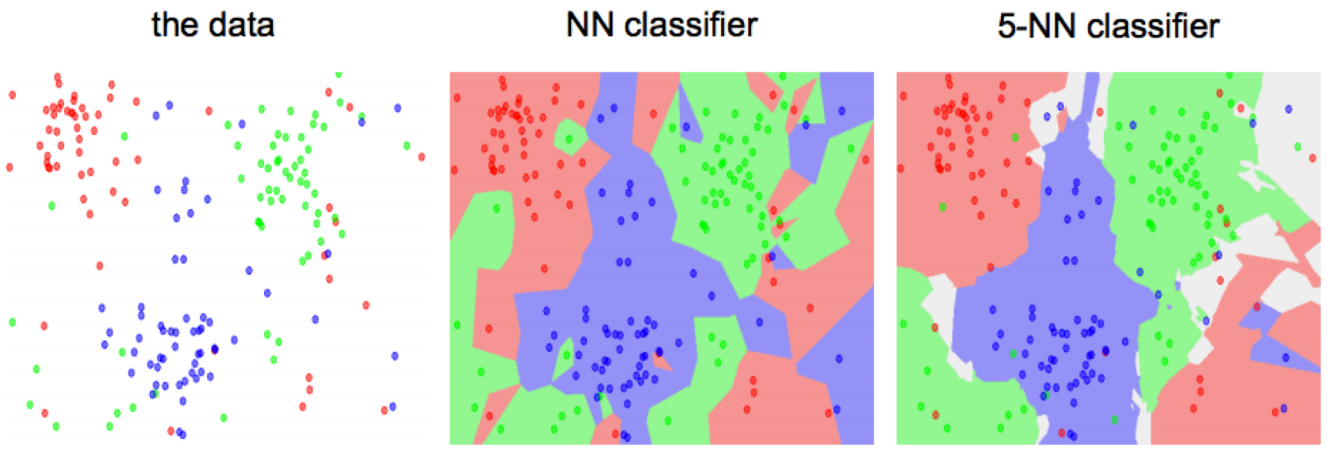

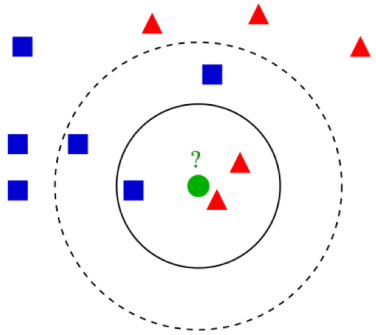

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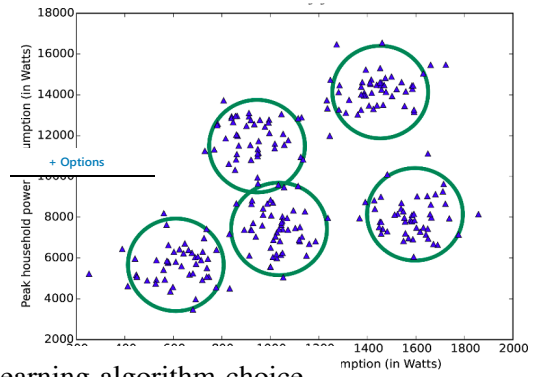
K-means
(data is not labeled)



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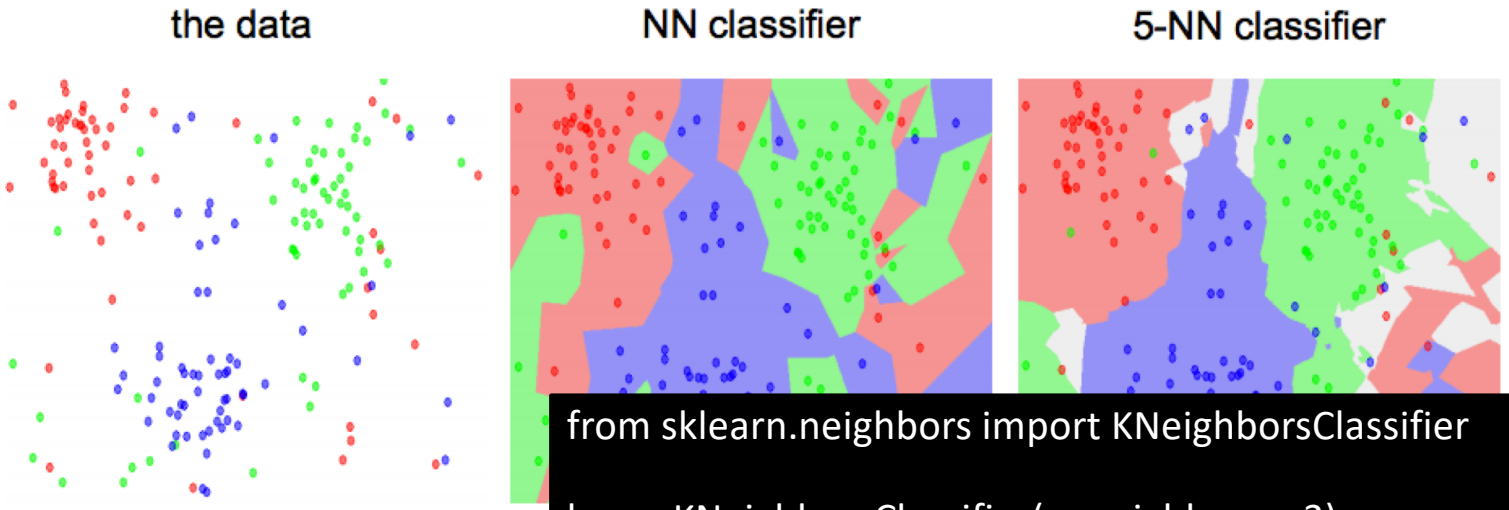
K Means / KNN Illustration



KNN Method: Find the k nearest images and have them vote on the label (i.e. take the mode)

```
from sklearn.neighbors import KNeighborsClassifier

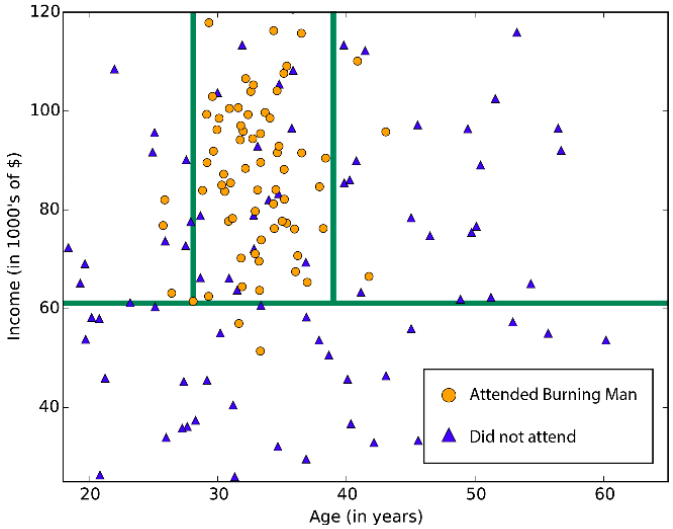
knn = KNeighborsClassifier(n_neighbors = 3)
knn.fit(X_train, Y_train)
Y_pred = knn.predict(X_test)

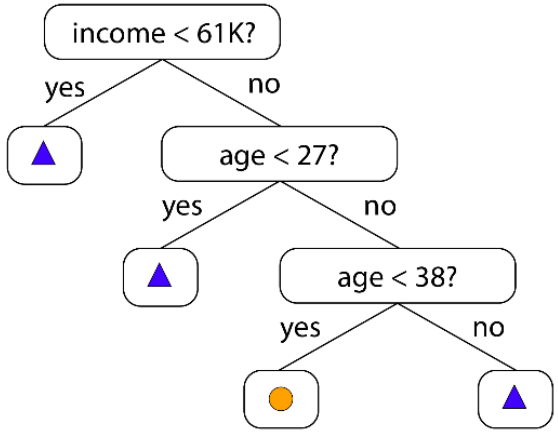
acc_knn = round(knn.score(X_train, Y_train) * 100, 2)
acc_knn

# or compare Y_pred with Y_test
```

Illustration Source: https://docs.mic

Decision Tree Illustration



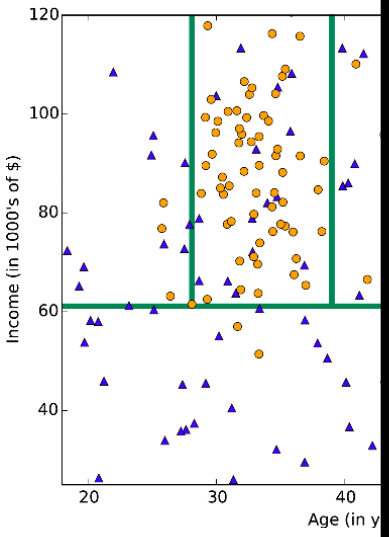


Person	F1(>61K)	F2 (<27y) …	Y
A	1	0	0
B	0	1	1
C	0	0	0
..	..	..	..

- Can be implemented in logic
- Complexity is in training
- Order of decisions matters for speed and accuracy

Illustration Source: https://docs.microsoft.com/en-us/azure/machine-learning/machine-learning-algorithm-choice

Decision Tree Illustration




```
from sklearn import tree

decision_tree = DecisionTreeClassifier()
decision_tree.fit(X_train, Y_train)
Y_pred = decision_tree.predict(X_test)

# Error
acc_decision_tree = round(decision_tree.score(X_train, Y_train) * 100, 2)
acc_decision_tree

# or compare Y_pred with Y_test
```

Illustration Source: http

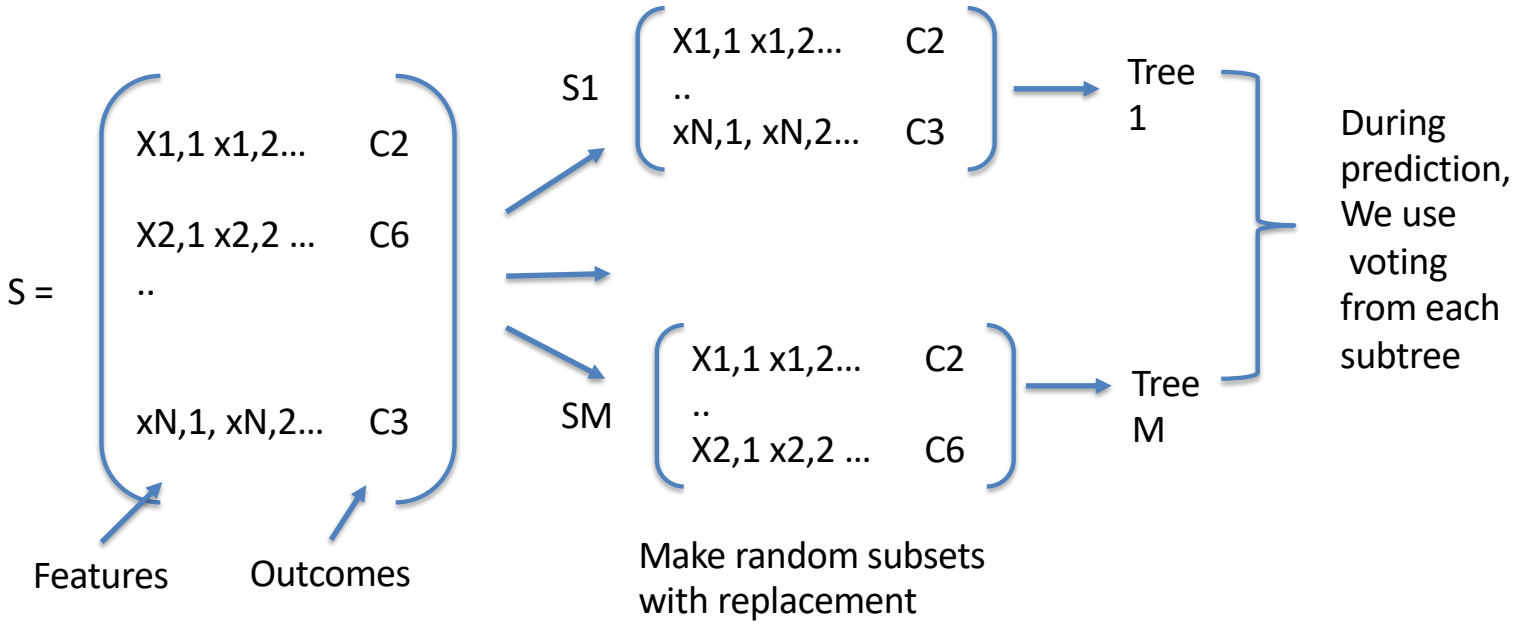
Our experiment with the Titanic Data Set

	Model	Score
	Random Forest	86.76
	Decision Tree	86.76
	KNN	84.74
	Support Vector Machines	83.84
	Logistic Regression	80.36
	Linear SVC	79.01
	Perceptron	78.00
	Naive Bayes	72.28
	Stochastic Gradient Decent	72.28

More Accuracy
Generally more training time
More risk of overfitting

Less Accuracy
Generally less computation

Random Forest – A type of bagging/ensemble approach



Advantages: One of most accurate
Efficient prediction over large data

Disadvantages: Overfit and Training time

Trees Can be Extended with Bagging

Explain bagging and Random Forrest

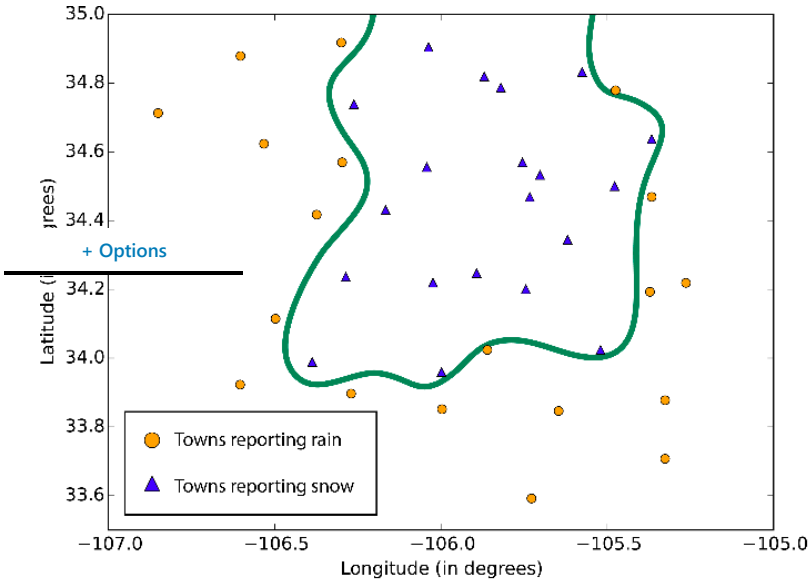
```
from sklearn.ensemble import RandomForestClassifier

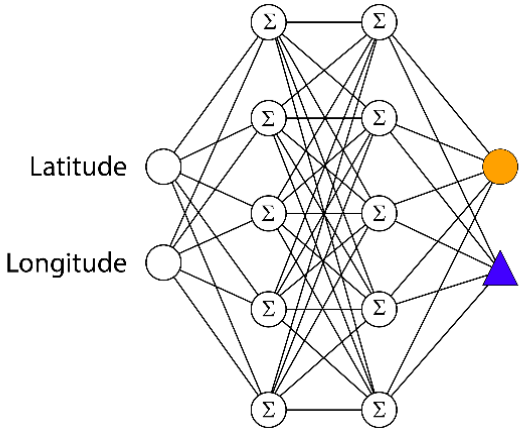
random_forest = RandomForestClassifier(n_estimators=1000)
random_forest.fit(X_train, Y_train)
Y_pred = random_forest.predict(X_test)
random_forest.score(X_train, Y_train)

# Error
acc_random_forest = round(random_forest.score(X_train, Y_train) * 100, 2)
acc_random_forest

# or compare Y_pred with Y_test
```

Neural Network Illustration





The boundaries learned by neural networks can be complex and irregular

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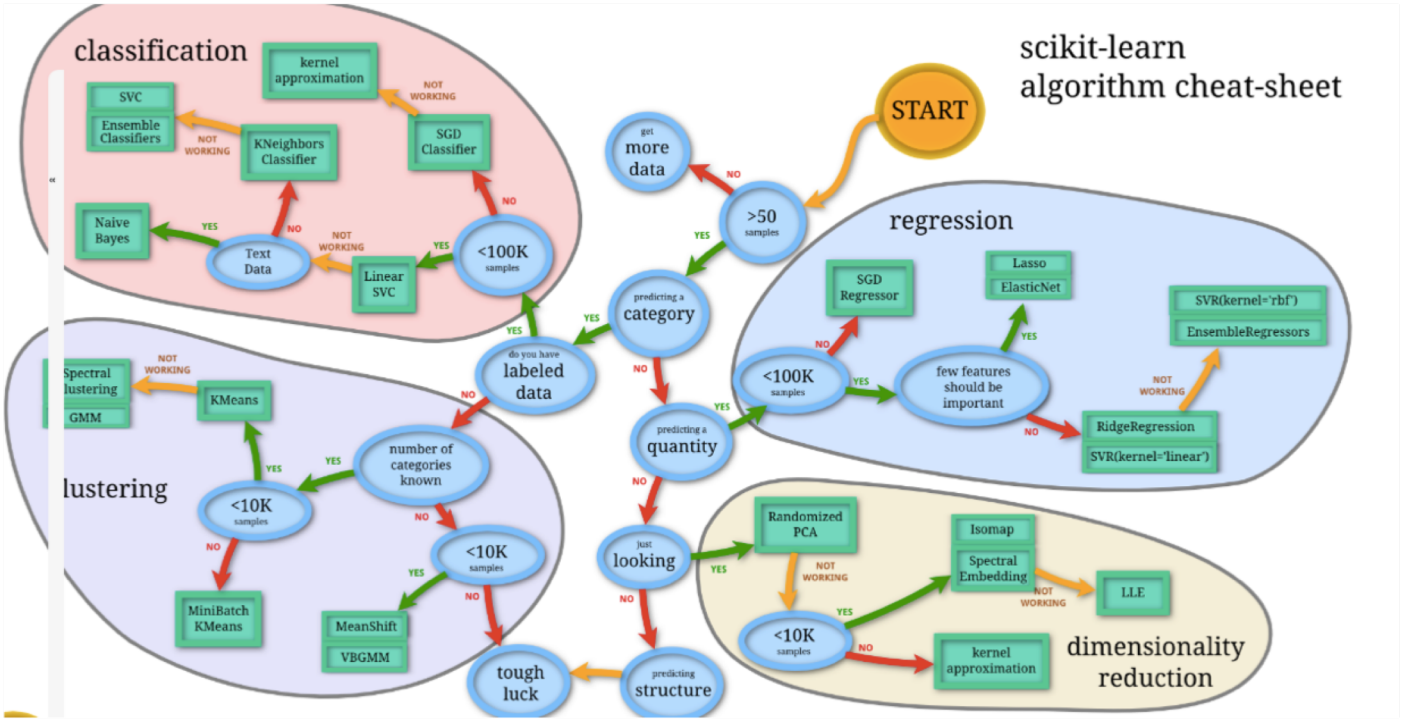
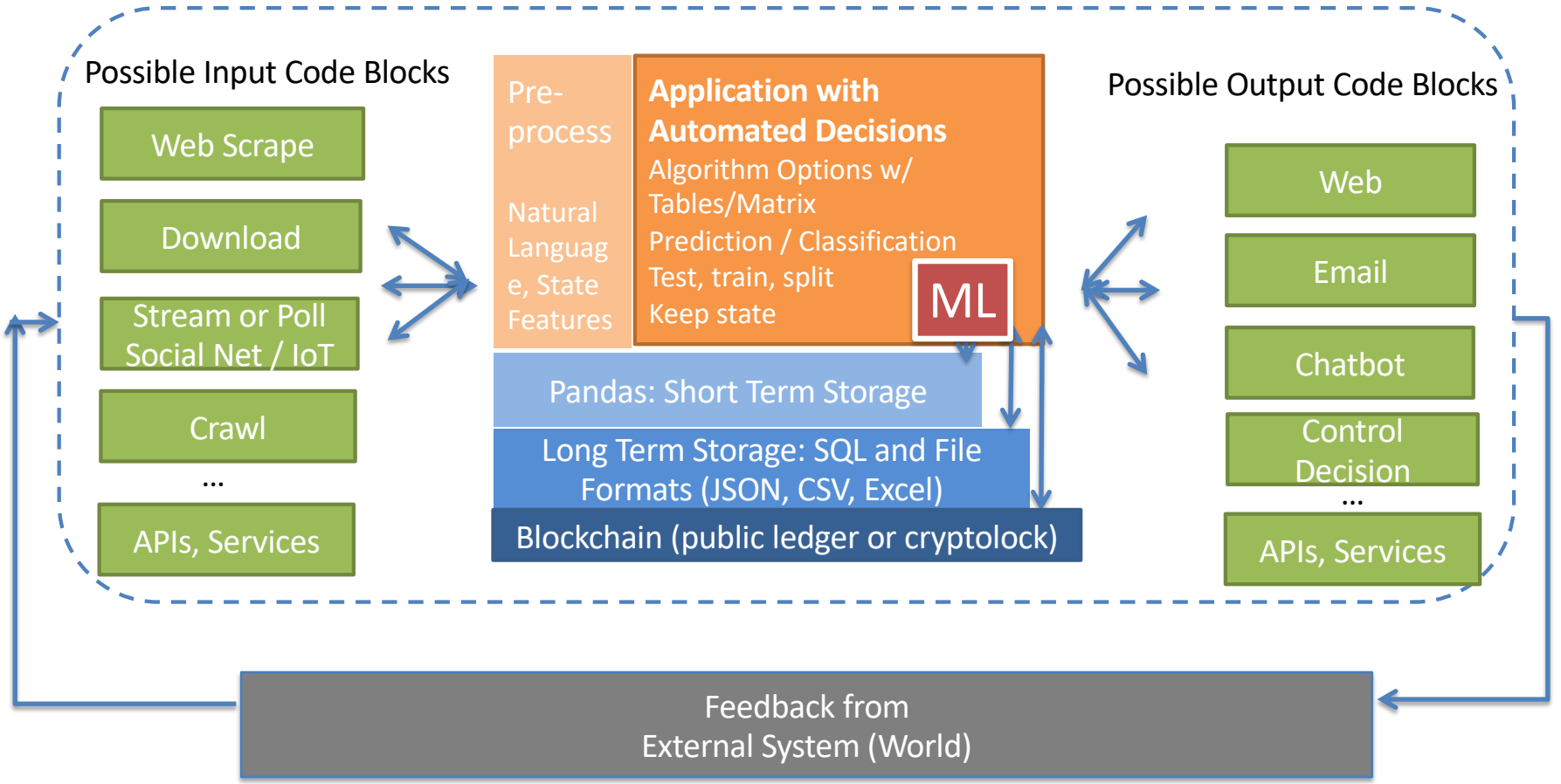
Scikit-Learn Algorithm



The Data-X System View: It's more than ML, it's also systems and models



End of Section