Data X

Machine Learning Summary with Illustrations

Part I – Setting UP for ML

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

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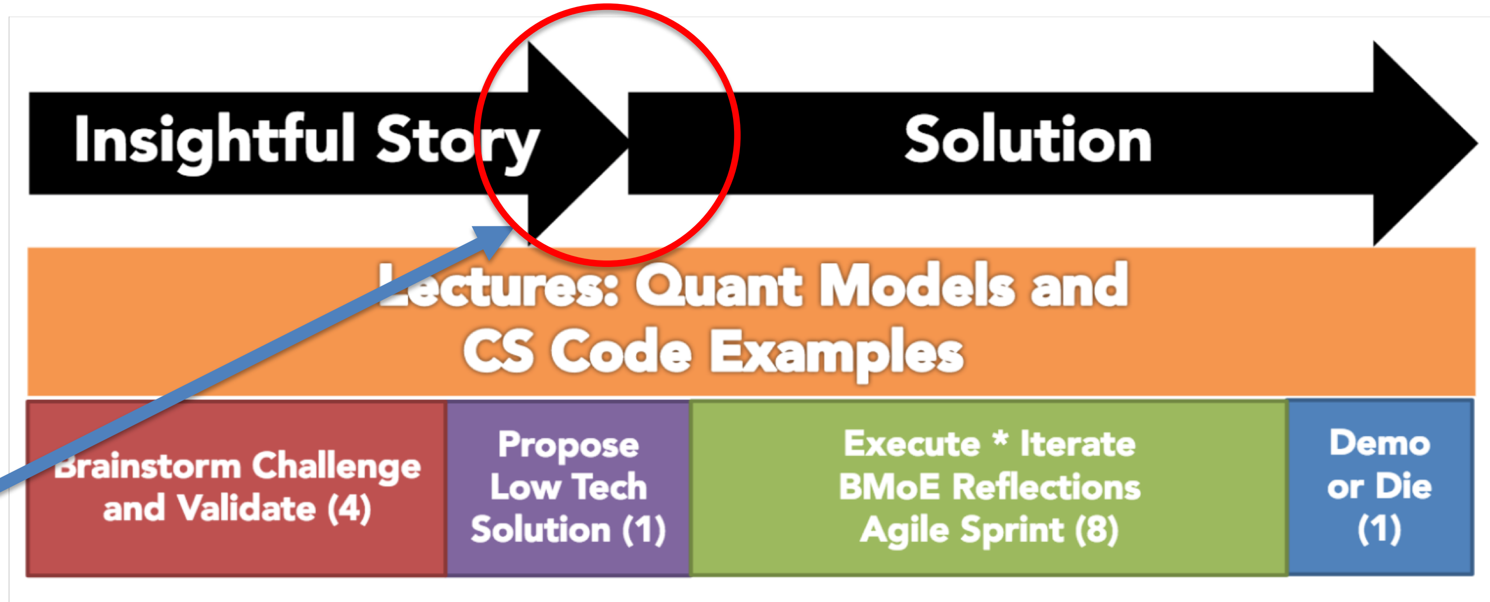
Course Overview

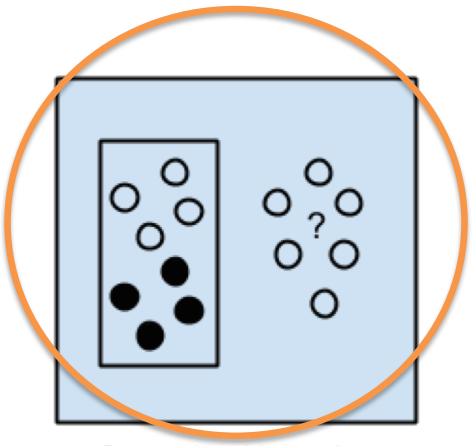
We are now here:

- tools
- theory

Titanic Notebook

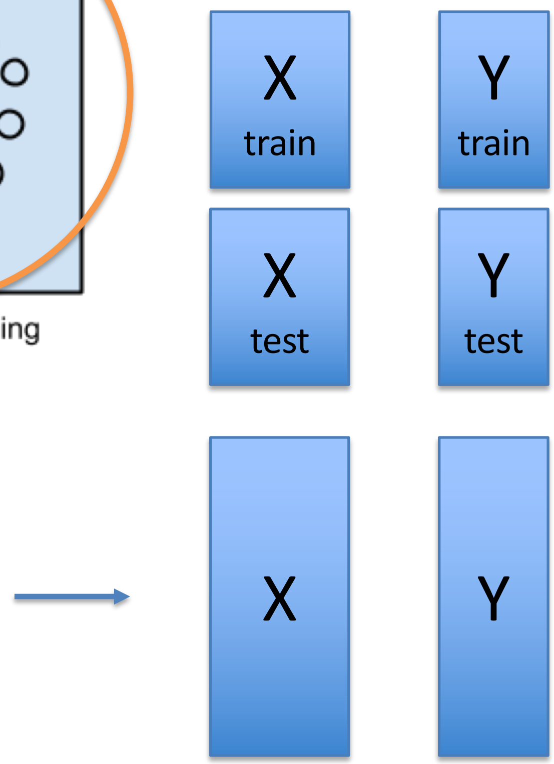


Open-ended, real-world project: Typically 5 students, with available advisor network



Supervised Learning Algorithms

Non-Labeled
Out of Sample



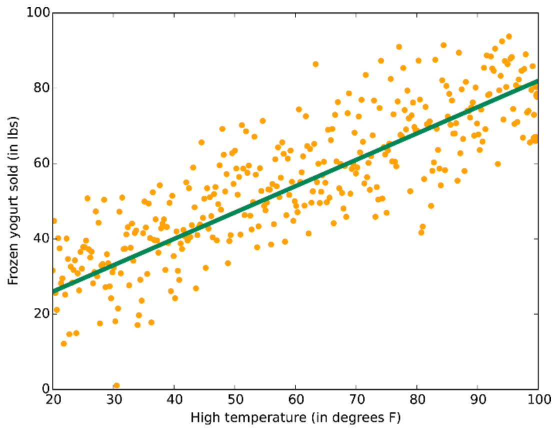
#Setting up for Supervised learning
First clean: use mapping + buckets

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

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

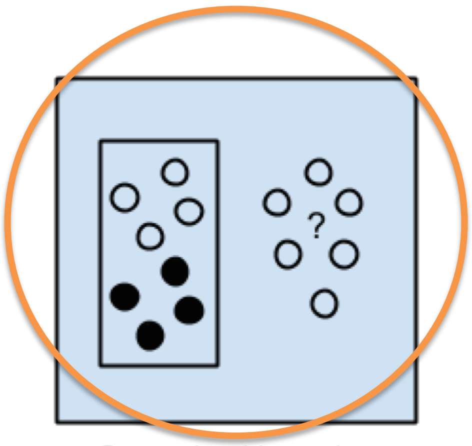
X_train = X[0:500]
Y_train = Y[0:500]
X_test = X[501:1000]
Y_test = Y[501:1000]

Linear Regression Illustration

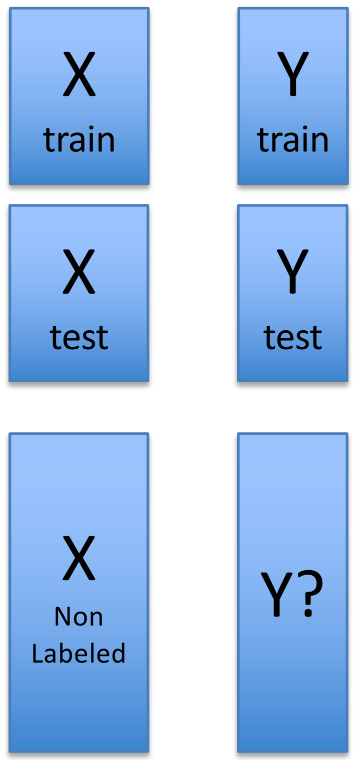



```
#Setting Linear Regression in sklearn
from sklearn import linear_model

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



Supervised Learning Algorithms



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

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

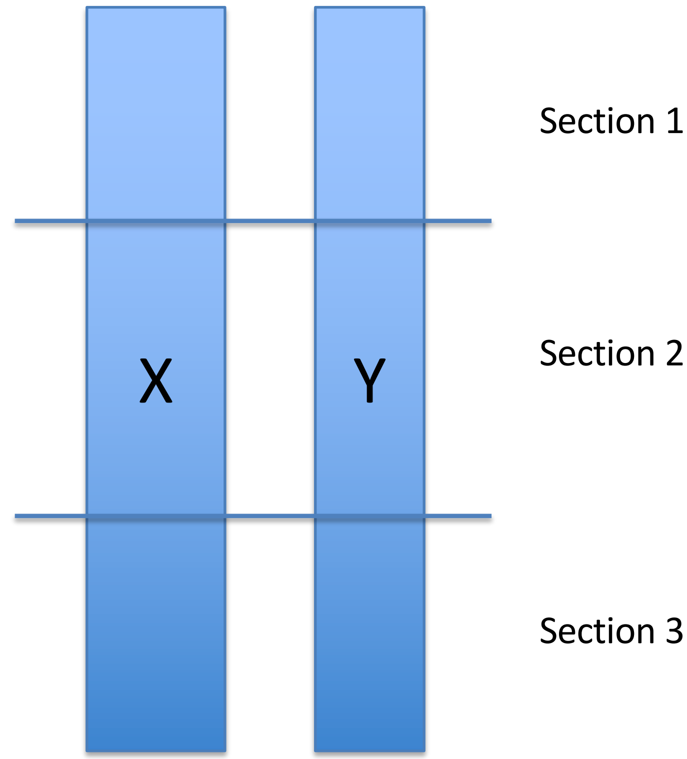
How to use the data efficiently?

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

# X = matrix of data – e.g 1000 rows
# 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]
```

- 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

- 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

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

This Section:

- Context of the Titanic notebook
- Setting up data tables for training and testing ML Models
- Linear regression example in Scikit for prediction
- Cross validation (k-fold)

Next Section: ML Algorithms for Classification

Data ^{X}

Machine Learning Summary with Illustrations
Part II – Using the Algorithms
Data X: A Course on Data, Signals, and Systems

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Titanic Notebook

Passenger List with ticket / cabin information → Data in Pandas Table Format → Clean Data Format for ML Models → Run Many ML Models to predict Survival

Passenger List

```
In [6]: # preview the data
        train_df.head()
```

Out[6]:

	PassengerId	Survived	Pclass	Name	Sex	Age	SibSp	Parch	Ticket	Fare	Cabin	Embarked
0	1	0	3	Braund, Mr. Owen Harris	male	22.0	1	0	A/5 21171	7.2500	NaN	S
1	2	1	1	Cumings, Mrs. John Bradley (Florence Briggs Th...	female	38.0	1	0	PC 17599	71.2833	C85	C
2	3	1	3	Heikkinen, Miss. Laina	female	26.0	0	0	STON/O2. 3101282	7.9250	NaN	S
3	4	1	1	Futrelle, Mrs. Jacques Heath (Lily May Peel)	female	35.0	1	0	113803	53.1000	C123	S
4	5	0	3	Allen, Mr. William Henry	male	35.0	0	0	373450	8.0500	NaN	S

Cleaned and Formatted

Out[35]:

	Survived	Pclass	Sex	Age	Fare	Embarked	Title	IsAlone	Age*Class
0	0	3	0	1	0	0	1	0	3
1	1	1	1	2	3	1	3	0	2
2	1	3	1	1	1	0	2	1	3
3	1	1	1	2	3	0	3	0	2
4	0	3	0	2	1	0	1	1	6
5	0	3	0	1	1	2	1	1	3
6	0	1	0	3	3	0	1	1	3

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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
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	Naive Bayes	72.28
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More Accuracy
Generally more training time
More risk of overfitting

Less Accuracy
Generally less computation

Logistic Regression Illustration

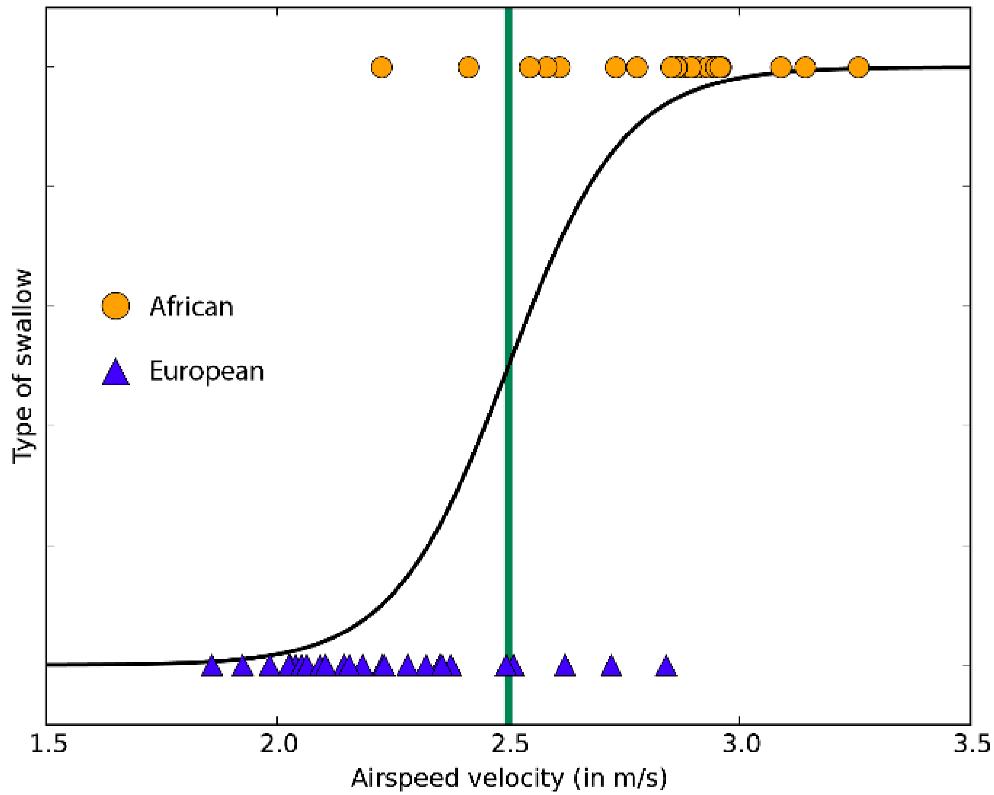
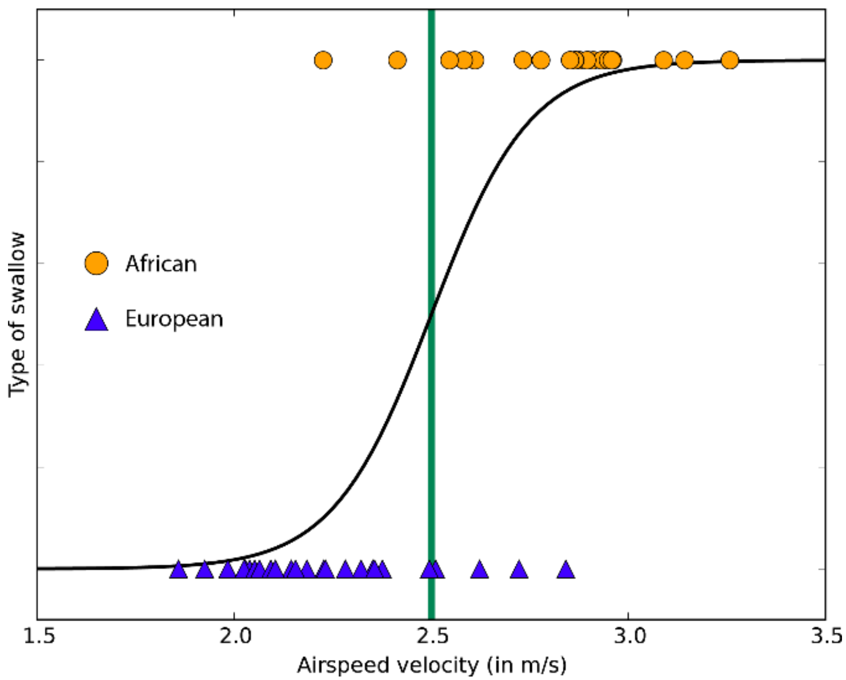


Illustration Source: https://docs.microsoft.com/en-us/azure/machine-learning/machine-learning-algorithm-choice

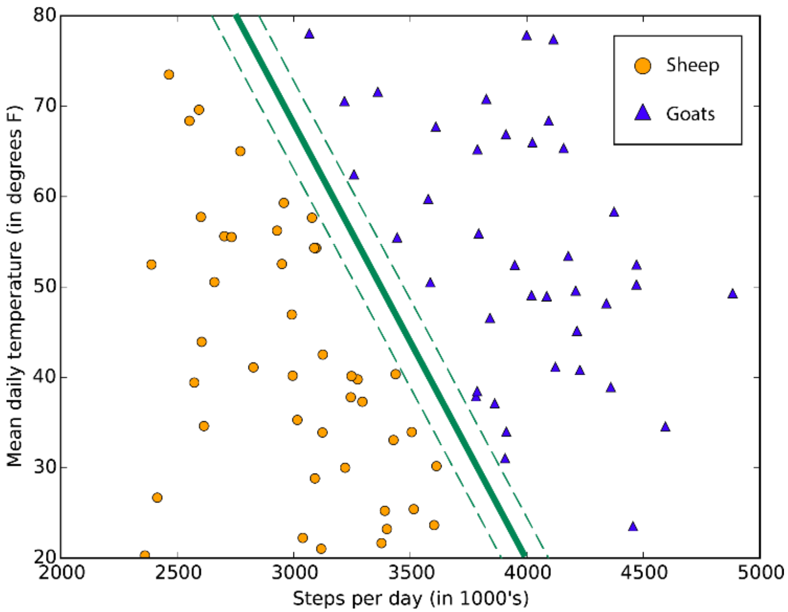
Logistic Regression Illustration




```
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
```

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

Support Vector Machine (SVM) Illustration



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

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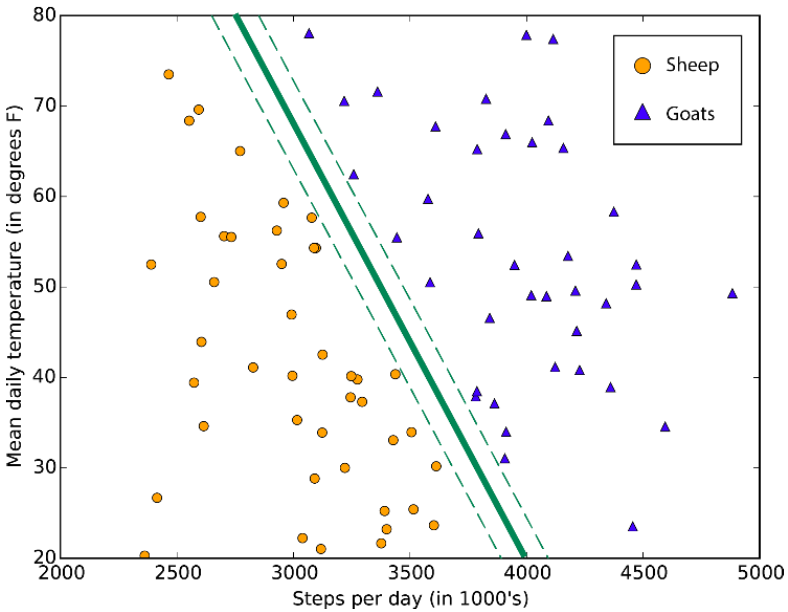

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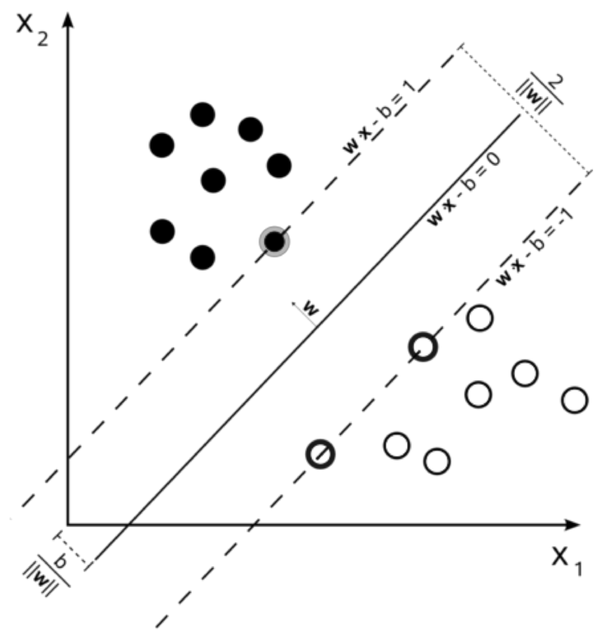


$\vec{w}\cdot\vec{x}-b=0,$

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

and

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

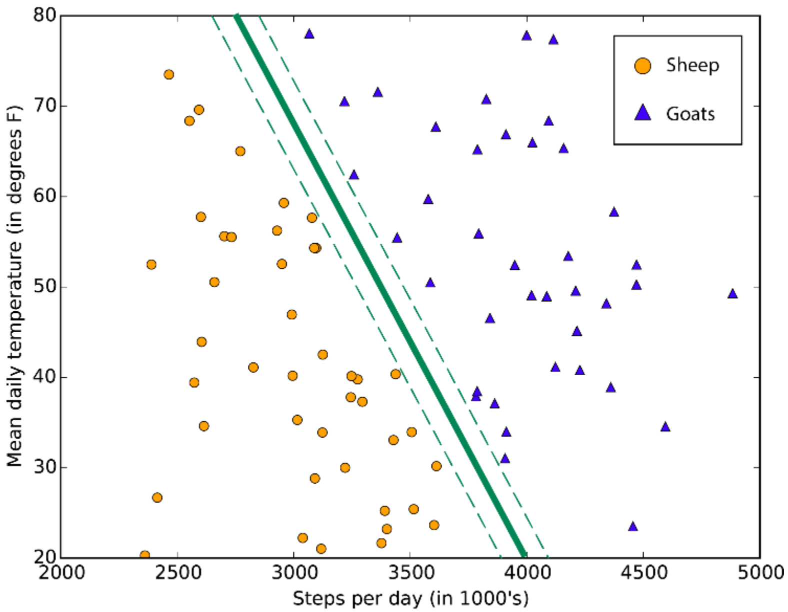
$\frac{b}{\|\vec{w}\|}$ determines the offset

Illustration Source:

Data X

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

Support Vector Machine (SVM) Illustration



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

SVM Considerations:

1. Robust
2. Effective in high dimension
3. Even when data rows < feature dimensions
4. Overfitting is possible, regularization is often needed
5. To predict for sparse data, must train with sparse data

Illustration Source:

Data X

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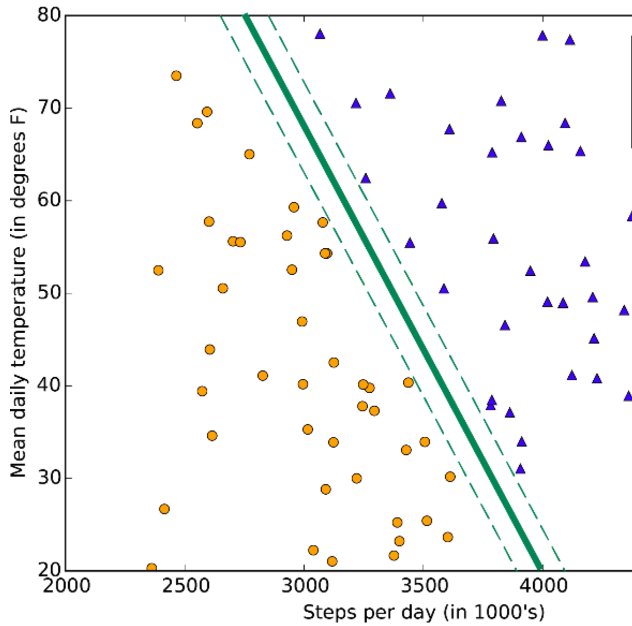
Support Vector Machine (SVM) Illustration



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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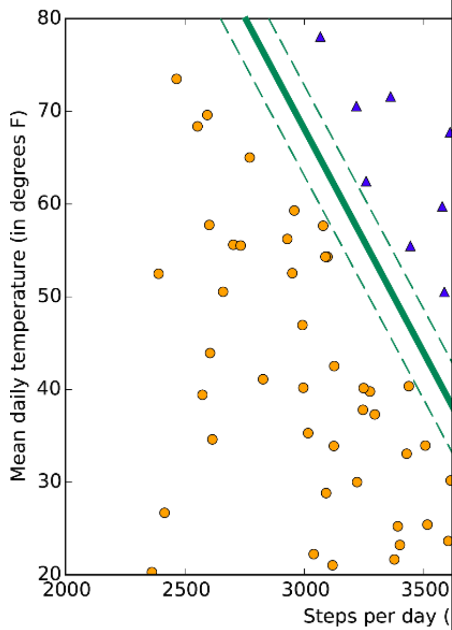


A typical support vector machine class boundary ma
classes

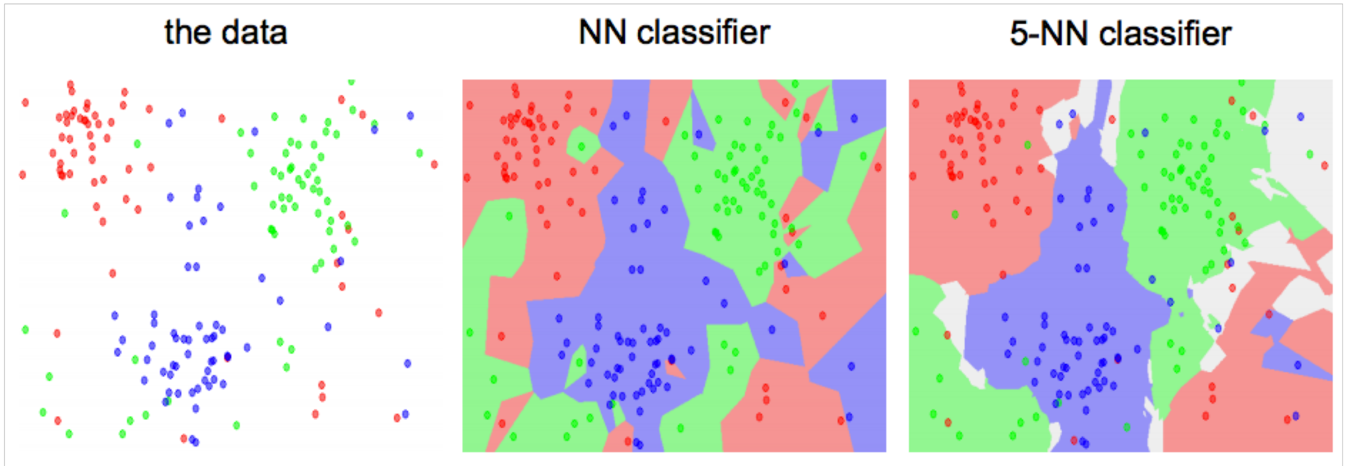
```
from sklearn.svm import SVC, LinearSVC

# 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
```

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

KNN / K Means Illustration

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

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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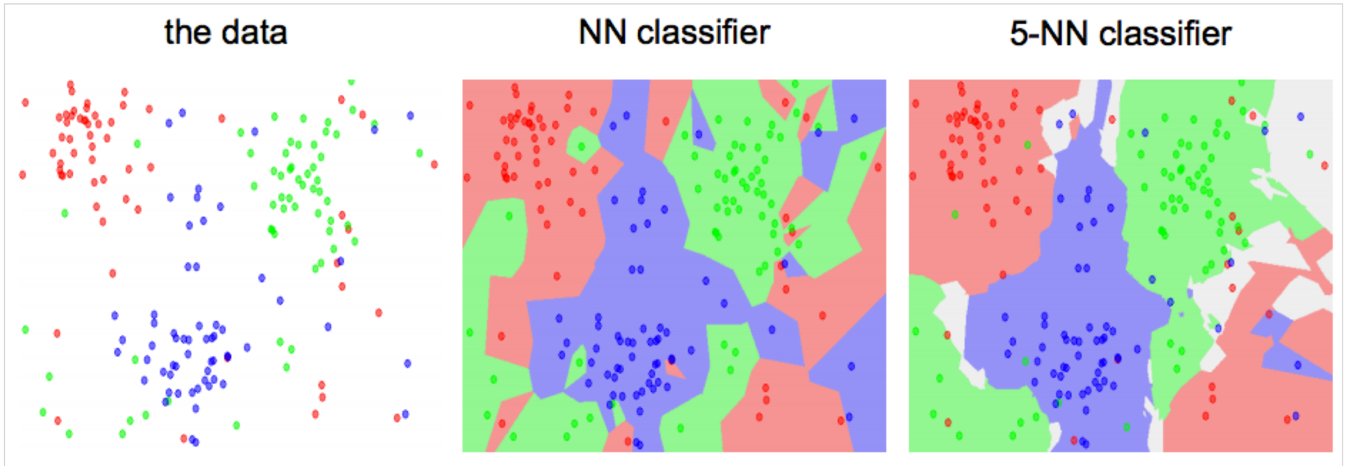

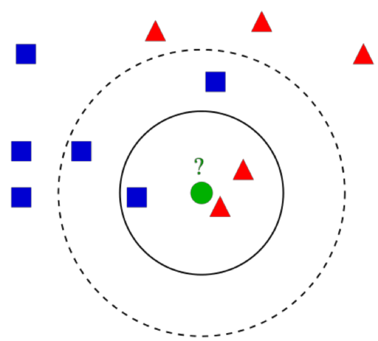

Example of *k*-NN classification. The test sample (green circle) should be classified either to the first class of blue squares or to the second class of red triangles. If *k = 3* (solid line circle) it is assigned to the second class because there are 2 triangles and only 1 square inside the inner circle.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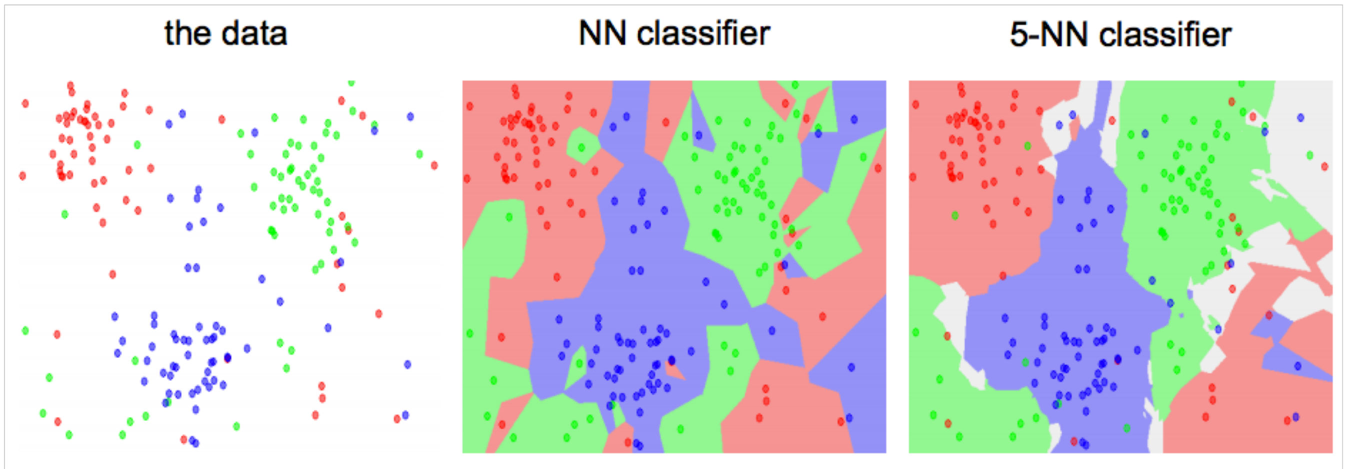

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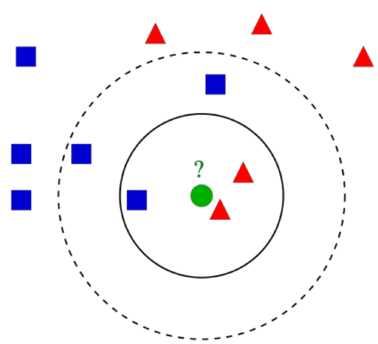
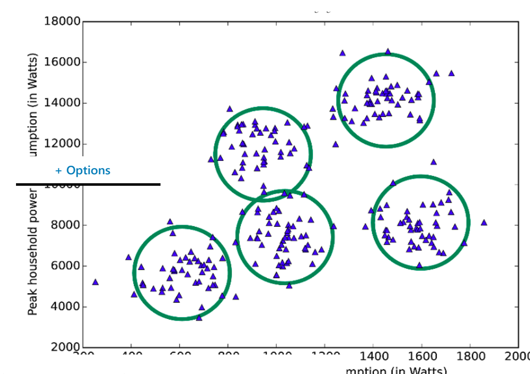


K-means
(data is not labeled)



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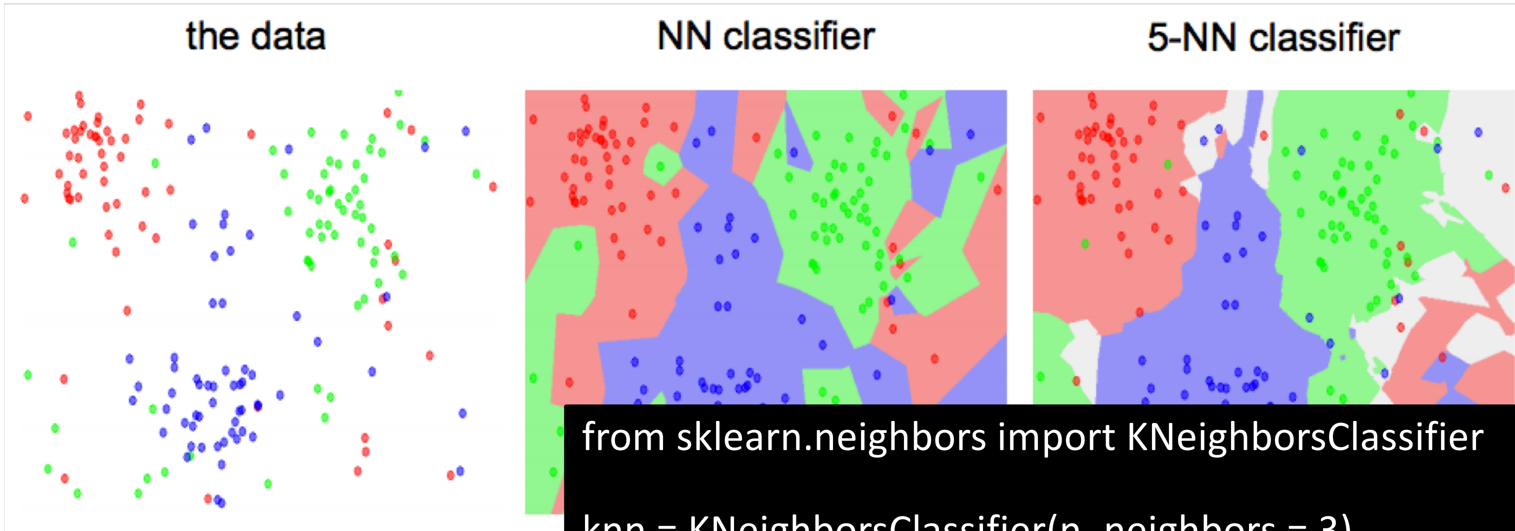
K Means / KNN Illustration

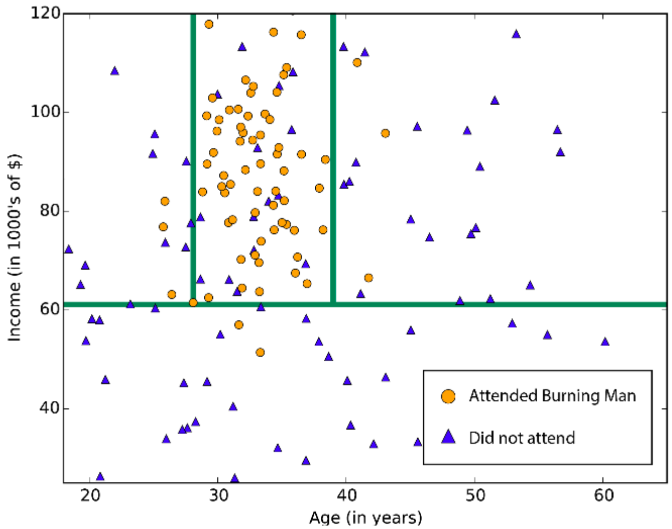


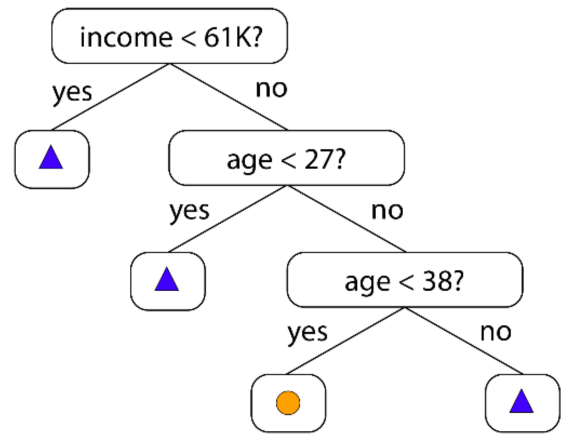

```
from sklearn.neighbors import KNeighborsClassifier

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
```

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

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

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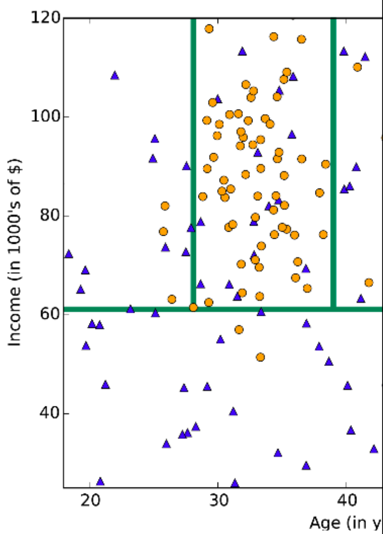
Decision Tree Illustration




```
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: htt

Data X

Our experiment with the Titanic Data Set

	Model	Score
	Random Forest	86.76
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	KNN	84.74
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	Naive Bayes	72.28
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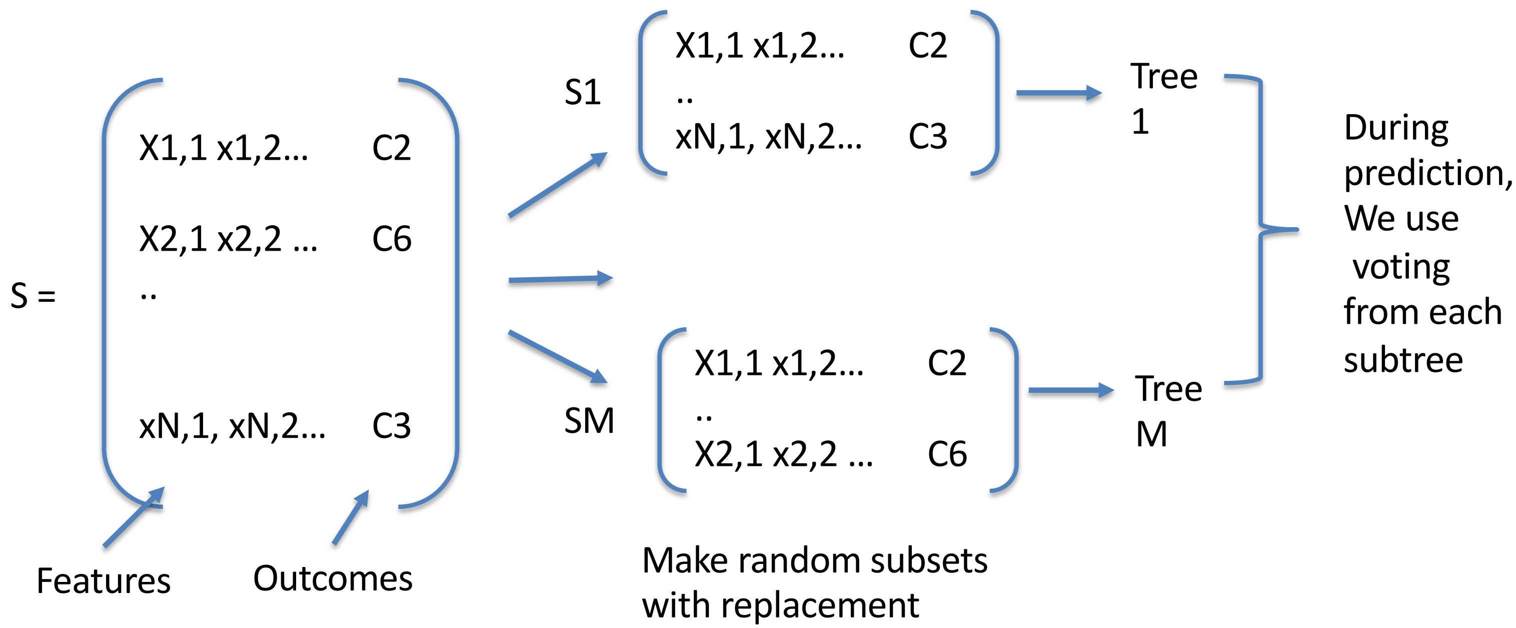
More Accuracy
Generally more training time
More risk of overfitting

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
```

Our experiment with the Titanic Data Set

	Model	Score
	Random Forest	86.76
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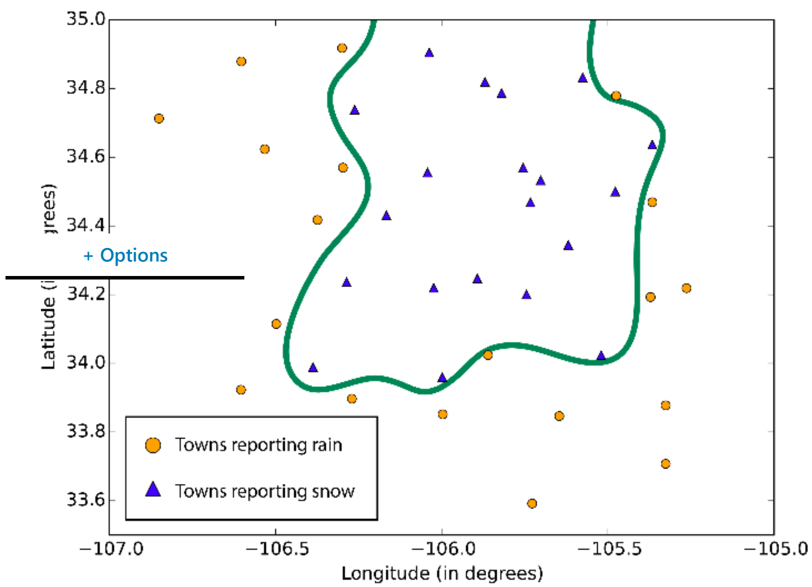
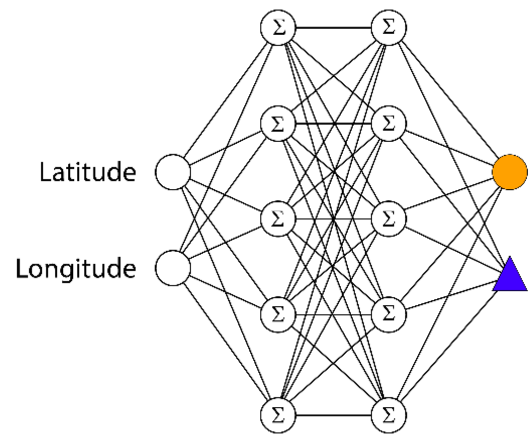
Neural Network Illustration

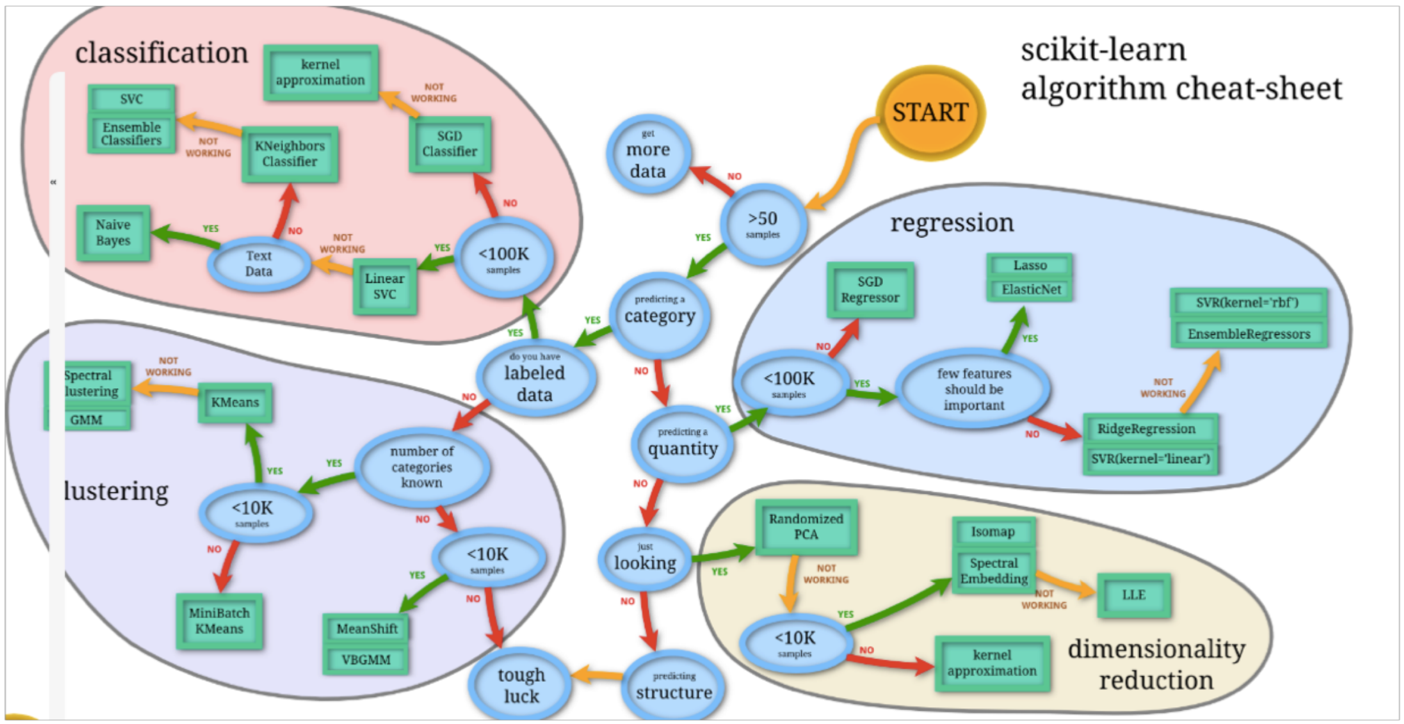




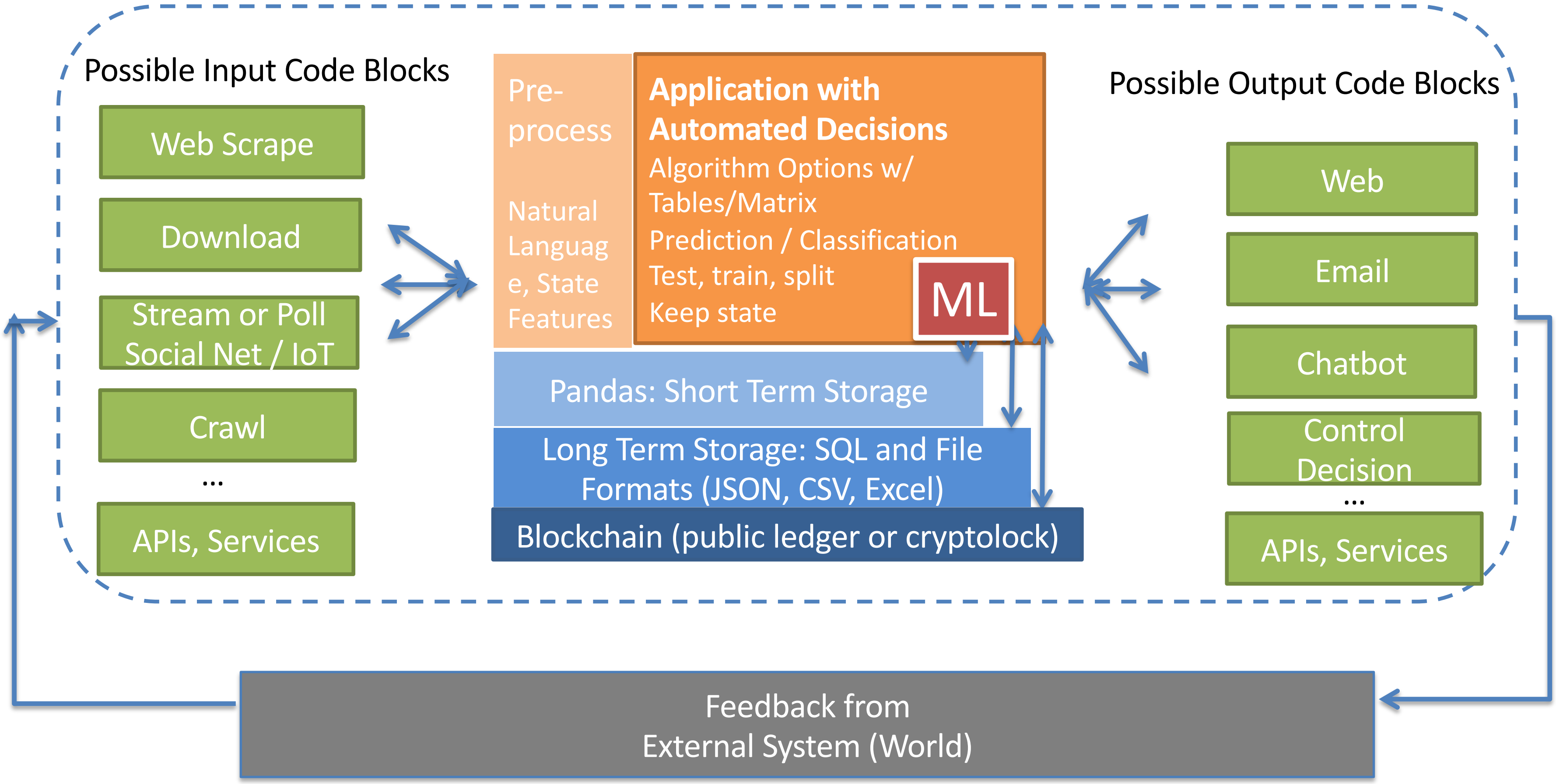
The boundaries learned by neural networks can be complex and irregular

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

Scikit-Learn Algorithm



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



End of Section