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# Spot-Check Regression Algorithm

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# Spot-Check Regression Algorithms

- Which algorithms will perform well on your machine learning problem?

# Algorithms Overview

Linear

- Linear Regression.
- Ridge Regression.
- LASSO Linear Regression.
- Elastic Net Regression.

Nonlinear

- k-Nearest Neighbors.
- Classication and Regression Trees.
- Support Vector Machines.

# Linear Regression

```
# Linear Regression
from pandas import read_csv
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.linear_model import LinearRegression filename
= 'housing.csv'
names = ['CRIM', 'ZN', 'INDUS', 'CHAS', 'NOX', 'RM', 'AGE', 'DIS', 'RAD',
'TAX', 'PTRATIO',
    'B', 'LSTAT', 'MEDV']
dataframe = read_csv(filename, delim_whitespace=True, names=names)
array = dataframe.values
X = array[:,0:13]
Y = array[:,13]
kfold = KFold(n_splits=10, random_state=7)
model = LinearRegression()
scoring = 'neg_mean_squared_error'
results = cross_val_score(model, X, Y, cv=kfold, scoring=scoring)
print(results.mean())
```

# Example Output

-34.7052559445

# Ridge Regression

```
# Ridge Regression
from pandas import read_csv
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.linear_model import Ridge
filename = 'housing.csv'
names = ['CRIM', 'ZN', 'INDUS', 'CHAS', 'NOX', 'RM', 'AGE', 'DIS', 'RAD',
'TAX','PTRATIO',
   'B', 'LSTAT', 'MEDV']
dataframe = read_csv(filename, delim_whitespace=True, names=names)
array = dataframe.values
X = array[:,0:13]
Y = array[:,13]
kfold = KFold(n_splits=10, random_state=7)
model = Ridge()
scoring = 'neg_mean_squared_error'
results = cross_val_score(model, X, Y, cv=kfold, scoring=scoring)
print(results.mean())
```

# Example Output

-34.0782462093

# LASSO Regression

```
# Lasso Regression
from pandas import read_csv
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.linear_model import Lasso
filename = 'housing.csv'
names = ['CRIM', 'ZN', 'INDUS', 'CHAS', 'NOX', 'RM', 'AGE', 'DIS', 'RAD', 'TAX',
'PTRATIO', 'B', 'LSTAT', 'MEDV']
dataframe = read_csv(filename, delim_whitespace=True, names=names)
array = dataframe.values
X = array[:,0:13]
Y = array[:,13]
kfold = KFold(n_splits=10, random_state=7)
model = Lasso()
scoring = 'neg_mean_squared_error'
results = cross_val_score(model, X, Y, cv=kfold, scoring=scoring)
print(results.mean())
```

# Example Output

-34.4640845883

# ElasticNet Regression

```
#ElasticNet Regression
from pandas import read_csv
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.linear_model import ElasticNet
filename = 'housing.csv'
names = ['CRIM', 'ZN', 'INDUS', 'CHAS', 'NOX', 'RM', 'AGE', 'DIS', 'RAD',
'TAX',
    'PTRATIO', 'B', 'LSTAT', 'MEDV']
dataframe = read_csv(filename, delim_whitespace=True,
names=names) array = dataframe.values
X = array[:,0:13]
Y = array[:,13]
kfold = KFold(n_splits=10, random_state=7)
model = ElasticNet()
scoring = 'neg_mean_squared_error'
results = cross_val_score(model, X, Y, cv=kfold,
scoring=scoring) print(results.mean())
```

# Example Output

-31.1645737142

# K-Nearest Neighbors

```
# KNN Regression
from pandas import read_csv
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.neighbors import KNeighborsRegressor
filename = 'housing.csv'
names = ['CRIM', 'ZN', 'INDUS', 'CHAS', 'NOX', 'RM', 'AGE', 'DIS', 'RAD',
'TAX',
    'PTRATIO', 'B', 'LSTAT', 'MEDV']
dataframe = read_csv(filename, delim_whitespace=True, names=names)
array = dataframe.values
X = array[:,0:13]
Y = array[:,13]
kfold = KFold(n_splits=10, random_state=7)
model = KNeighborsRegressor()
scoring = 'neg_mean_squared_error'
results = cross_val_score(model, X, Y, cv=kfold, scoring=scoring)
print(results.mean())
```

# Example Output

-107.28683898

# Classification and Regression Trees

```
#Decision Tree Regression
from pandas import read_csv
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.tree import DecisionTreeRegressor
filename = 'housing.csv
names = ['CRIM', 'ZN', 'INDUS', 'CHAS', 'NOX', 'RM', 'AGE', 'DIS', 'RAD',
'TAX',
    'PTRATIO', 'B', 'LSTAT', 'MEDV']
dataframe = read_csv(filename, delim_whitespace=True, names=names)
array = dataframe.values
X = array[:,0:13]
Y = array[:,13]
kfold = KFold(n_splits=10, random_state=7)
model = DecisionTreeRegressor()
scoring = 'neg_mean_squared_error'
results = cross_val_score(model, X, Y, cv=kfold, scoring=scoring)
print(results.mean())
```

# Example Output

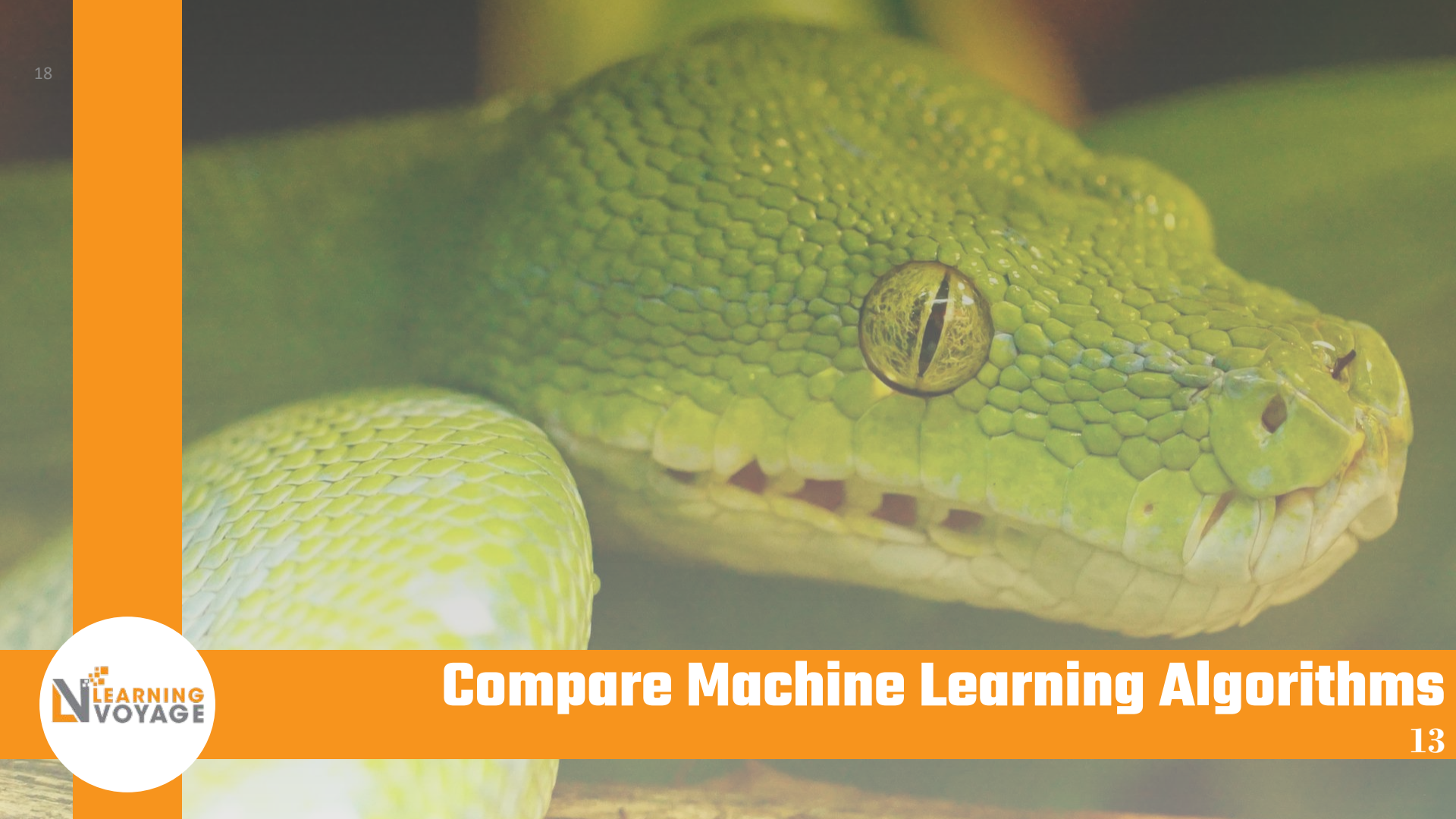
-35.4906027451

# Support Vector Machines

```
# SVM Regression
from pandas import read_csv
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.svm import SVR
filename = 'housing.csv'
names = ['CRIM', 'ZN', 'INDUS', 'CHAS', 'NOX', 'RM', 'AGE', 'DIS', 'RAD',
'TAX',
    'PTRATIO', 'B', 'LSTAT', 'MEDV']
dataframe = read_csv(filename, delim_whitespace=True, names=names)
array = dataframe.values
X = array[:,0:13]
Y = array[:,13]
kfold = KFold(n_splits=10, random_state=7)
model = SVR(gamma='auto')
scoring = 'neg_mean_squared_error'
results = cross_val_score(model, X, Y, cv=kfold, scoring=scoring)
print(results.mean())
```

# Example Output

-91.0478243332



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# Compare Machine Learning Algorithms

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# Choose the Best Machine Learning Model

- Use resampling methods to get an estimate of model accuracy
- Visualize the data using different techniques

# Compare Machine Learning Algorithms Consistently

- Evaluate each algorithm on a consistent test harness

- For our example, compare six different Classification algorithms:
  - Logistic Regression
  - Linear Discriminant Analysis
  - k-Nearest Neighbors
  - Classification and Regression Trees
  - Naive Bayes
  - Support Vector Machines

# Example

```
# Compare Algorithms
from pandas import read_csv
from matplotlib import pyplot
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
from sklearn.naive_bayes import GaussianNB
from sklearn.svm import SVC
# load dataset
filename = 'pima-indians-diabetes.data.csv'
names = ['preg', 'plas', 'pres', 'skin', 'test', 'mass', 'pedi', 'age', 'class']
dataframe = read_csv(filename, names=names)
array = dataframe.values
X = array[:,0:8]
Y = array[:,8]
#prepare models
models = []
models.append(('LR', LogisticRegression(solver='liblinear')))
models.append(('LDA', LinearDiscriminantAnalysis()))
models.append(('KNN', KNeighborsClassifier()))
models.append(('CART', DecisionTreeClassifier()))
```

# Example (continued)

```
models.append(('SVM', SVC(gamma='auto')))
# evaluate each model in turn
results = []
names = []
scoring = 'accuracy'
for name, model in models:
        kfold = KFold(n_splits=10, random_state=7)
        cv_results = cross_val_score(model, X, Y, cv=kfold, scoring=scoring)
        results.append(cv_results)
        names.append(name)
        msg = "%s: %f (%f)" % (name, cv_results.mean(), cv_results.std())
        print(msg)
# boxplot algorithm comparison
fig = pyplot.figure()
fig.suptitle('AlgorithmComparison')
ax = fig.add_subplot(111)
pyplot.boxplot(results)
ax.set_xticklabels(names)
pyplot.show()
```

# Example Output

LR: 0.769515 (0.048411)

LDA: 0.773462 (0.051592)

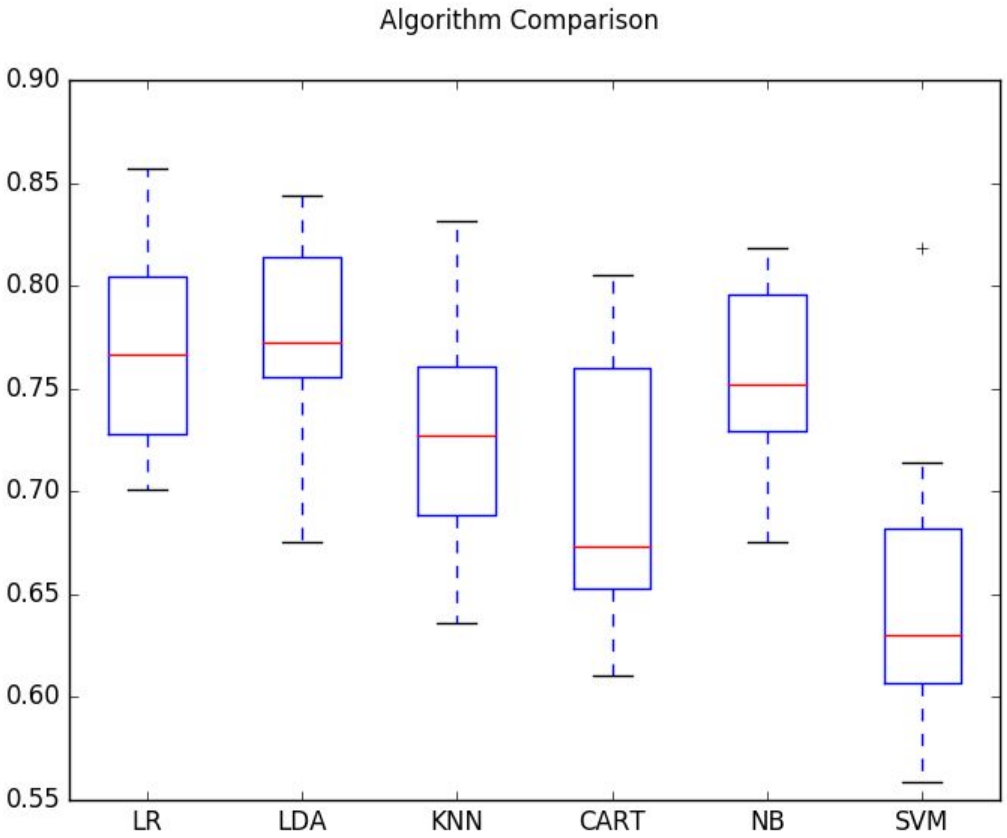
KNN: 0.726555 (0.061821)

CART: 0.695232 (0.062517)

NB: 0.755178 (0.042766)

SVM: 0.651025 (0.072141)

# Example Box and Whisker Plots



# Automate Machine Learning Workflows with Pipelines

# Automating Machine Learning Workflows

- Standard Workflows combat data leakage
- Python scikit-learn provides a pipeline utility

# Data Preparation and Modeling Pipeline

- Data leakage can occur during data preparation
- Pipelines help to prevent data leakage
- Pipeline steps
  - Standardize the data
  - Learn a linear discriminant analysis model

# Pipeline Example

```
# Create a pipeline that standardizes the data then creates a model
from pandas import read_csv
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.preprocessing import StandardScaler
from sklearn.pipeline import Pipeline
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
# load data
filename = 'pima-indians-diabetes.data.csv'
names = ['preg', 'plas', 'pres', 'skin', 'test', 'mass', 'pedi', 'age',
'class']
dataframe = read_csv(filename, names=names)
array = dataframe.values
X = array[:,0:8]
```

# Pipeline Example (continued)

```
# create pipeline
estimators = []
estimators.append(('standardize', StandardScaler()))
estimators.append(('lda', LinearDiscriminantAnalysis()))
model = Pipeline(estimators)
# evaluate pipeline
kfold = KFold(n_splits=10, random_state=7)
results = cross_val_score(model, X, Y, cv=kfold)
print(results.mean())
```

# Pipeline Example Output


0.773462064252

# Feature Extraction and Modeling Pipeline

- Feature extraction is also susceptible to data leakage
- Pipeline steps to prevent data leakage
  - Feature extraction with principal component analysis
  - Feature extraction with statistical selection
  - Feature union
  - Learn a logistic regression model

# Pipeline Example

```
#Create a pipeline that extracts features from the data then creates a model
from pandas import read_csv
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.pipeline import Pipeline
from sklearn.pipeline import FeatureUnion
from sklearn.linear_model import LogisticRegression
from sklearn.decomposition import PCA
from sklearn.feature_selection import SelectKBest
#load data
filename = 'pima-indians-diabetes.data.csv'
names = ['preg', 'plas', 'pres', 'skin', 'test', 'mass', 'pedi', 'age', 'class']
dataframe = read_csv(filename, names=names)
array = dataframe.values
X = array[:,0:8]
Y = array[:,8]
#create feature union
features = []
features.append(('pca', PCA(n_components=3)))
features.append(('select_best', SelectKBest(k=6)))
feature_union = FeatureUnion(features)
```

# Pipeline Example (continued)

```
#create pipeline
estimators = []
estimators.append(('feature_union', feature_union))
estimators.append(('logistic', LogisticRegression(solver='liblinear')))
model = Pipeline(estimators)
# evaluate pipeline
kfold = KFold(n_splits=10, random_state=7)
results = cross_val_score(model, X, Y, cv=kfold)
print(results.mean())
```

# Pipeline Example Output



0.776042378674

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# Improve Performance with Ensembles

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# Combine Models Into Ensemble Predictions

- Three most popular methods for combining the predictions from different models
  - Bagging
  - Boosting
  - Voting

# Bagging Algorithms

- Bagged Decision Trees
- Random Forest
- Extra Trees

# Bagged Decision Trees

```
#Bagged Decision Trees for Classification
from pandas import read_csv
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.ensemble import BaggingClassifier
from sklearn.tree import DecisionTreeClassifier
filename = 'pima-indians-diabetes.data.csv'
names = ['preg', 'plas', 'pres', 'skin', 'test', 'mass', 'pedi', 'age',
'class']
dataframe = read_csv(filename, names=names)
array = dataframe.values
X = array[:,0:8]
Y = array[:,8]
seed = 7
kfold = KFold(n_splits=10, random_state=seed)
cart = DecisionTreeClassifier()
num_trees = 100
model = BaggingClassifier(base_estimator=cart, n_estimators=num_trees,
random_state=seed) results = cross_val_score(model, X, Y, cv=kfold)
print(results.mean())
```

# Example Output

0.770745044429

# Random Forest

```
#Random Forest Classification
from pandas import read_csv
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.ensemble import RandomForestClassifier
filename = 'pima-indians-diabetes.data.csv'
names = ['preg', 'plas', 'pres', 'skin', 'test', 'mass', 'pedi', 'age',
'class']
dataframe = read_csv(filename, names=names)
array = dataframe.values
X = array[:,0:8]
Y = array[:,8]
num_trees = 100
max_features = 3
kfold = KFold(n_splits=10, random_state=7)
model = RandomForestClassifier(n_estimators=num_trees,max_features=
max_features)
results = cross_val_score(model, X, Y, cv=kfold)
print(results.mean())
```

# Example Output

0.770727956254

# Extra Trees

```
#Extra Trees Classification
from pandas import read_csv
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.ensemble import ExtraTreesClassifier
filename = 'pima-indians-diabetes.data.csv'
names = ['preg', 'plas', 'pres', 'skin', 'test', 'mass', 'pedi', 'age',
'class']
dataframe = read_csv(filename, names=names)
array = dataframe.values
X = array[:,0:8]
Y = array[:,8]
num_trees = 100
max_features = 7
kfold = KFold(n_splits=10, random_state=7)
model = ExtraTreesClassifier(n_estimators=num_trees,
max_features=max_features)
results = cross_val_score(model, X, Y, cv=kfold)
print(results.mean())
```

# Example Output

0.760269993165

# Boosting Algorithms

- AdaBoost
- Stochastic Gradient Boosting

# AdaBoost

```
#AdaBoost Classification
from pandas import read_csv
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.ensemble import AdaBoostClassifier
filename = 'pima-indians-diabetes.data.csv'
names = ['preg', 'plas', 'pres', 'skin', 'test', 'mass', 'pedi', 'age',
'class']
dataframe = read_csv(filename, names=names)
array = dataframe.values
X = array[:,0:8]
Y = array[:,8]
num_trees = 30
seed=7
kfold = KFold(n_splits=10, random_state=seed)
model = AdaBoostClassifier(n_estimators=num_trees, random_state=seed)
results = cross_val_score(model, X, Y, cv=kfold)
print(results.mean())
```

# Example Output

0.76045796309

# Stochastic Gradient Boosting

```
#Stochastic Gradient Boosting Classification
from pandas import read_csv
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.ensemble import GradientBoostingClassifier
filename = 'pima-indians-diabetes.data.csv'
names = ['preg', 'plas', 'pres', 'skin', 'test', 'mass', 'pedi', 'age',
'class']
dataframe = read_csv(filename, names=names)
array = dataframe.values
X = array[:,0:8]
Y = array[:,8]
seed = 7
num_trees = 100
kfold = KFold(n_splits=10, random_state=seed)
model = GradientBoostingClassifier(n_estimators=num_trees,random_state=seed)
results = cross_val_score(model, X, Y, cv=kfold)
print(results.mean())
```

# Example Output

0.764285714286

# Voting Ensemble

```
#Voting Ensemble for Classification
from pandas import read_csv
from sklearn.model_selection import KFold
from sklearn.model_selection import cross_val_score
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.svm import SVC
from sklearn.ensemble import VotingClassifier
filename = 'pima-indians-diabetes.data.csv'
names = ['preg', 'plas', 'pres', 'skin', 'test', 'mass', 'pedi', 'age',
'class']
dataframe = read_csv(filename, names=names)
array = dataframe.values
X = array[:,0:8]
Y = array[:,8]
kfold = KFold(n_splits=10, random_state=7)
#create the sub models
estimators = []
model1 = LogisticRegression(solver= 'liblinear')
```

# Example (continued)

```
model2 = DecisionTreeClassifier()
estimators.append(('cart', model2))
model3 = SVC(gamma='auto')
estimators.append(('svm', model3))
# create the ensemble model
ensemble = VotingClassifier(estimators)
results = cross_val_score(ensemble, X, Y, cv=kfold)
print(results.mean())
```

# Example Output



0.729049897471

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# Improve Performance with Algorithm Tuning

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# Machine Learning Algorithm Parameters

- Grid Search Parameter Tuning
- Random Search Parameter Tuning

# Grid Search Parameter Tuning

```
#Grid Search for Algorithm Tuning
import numpy
from pandas import read_csv
from sklearn.linear_model import RidgeClassifier
from sklearn.model_selection import GridSearchCV
filename = 'pima-indians-diabetes.data.csv'
names = ['preg', 'plas', 'pres', 'skin', 'test', 'mass', 'pedi', 'age',
'class']
dataframe = read_csv(filename, names=names)
array = dataframe.values
X = array[:,0:8]
Y = array[:,8]
alphas = numpy.array([1,0.1,0.01,0.001,0.0001,0])
param_grid = dict(alpha=alphas)
model = RidgeClassifier()
grid = GridSearchCV(estimator=model, param_grid=param_grid,
cv=3) grid.fit(X, Y)
print(grid.best_score_)
```

# Example Output

0.7708333333333334

1.0

# Random Search Parameter Tuning

```
#Randomized for Algorithm Tuning
from pandas import read_csv
from scipy.stats import uniform
from sklearn.linear_model import RidgeClassifier
from sklearn.model_selection import RandomizedSearchCV
filename = 'pima-indians-diabetes.data.csv'
names = ['preg', 'plas', 'pres', 'skin', 'test', 'mass', 'pedi', 'age',
'class'] dataframe = read_csv(filename, names=names)
array = dataframe.values
X = array[:,0:8]
Y = array[:,8]
param_grid = {'alpha': uniform()}
model = RidgeClassifier()
rsearch = RandomizedSearchCV(estimator=model,
param_distributions=param_grid,
    n_iter=100, cv=3, random_state=7)
rsearch.fit(X, Y)
print(rsearch.best_score_)
print(rsearch.best_estimator_.alpha)
```

0.7708333333333334

0.7799187922401146

# Save and Load Machine Learning Models

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# Finalize Your Model with pickle

```
#Save Model Using Pickle
from pandas import read_csv
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from pickle import dump
from pickle import load
filename = 'pima-indians-diabetes.data.csv'
names = ['preg', 'plas', 'pres', 'skin', 'test', 'mass', 'pedi', 'age',
'class'] dataframe = read_csv(filename, names=names)
array = dataframe.values
X = array[:,0:8]
Y = array[:,8]
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.33,
random_state=7)
# Fit the model on 33%
model = LogisticRegression(solver= 'liblinear')
model.fit(X_train, Y_train)
#save the model to disk0
filename = 'Finalized model.sav'
```

# Example (continued)

```
dump(model, open(filename, 'wb'))

some time later...

load the model from disk
loaded_model = load(open(filename, 'rb'))
result = loaded_model.score(X_test, Y_test)
print(result)
```

# Example Output

0.755905511811

# Finalize your Model with Joblib

```
#Save Model Using joblib
from pandas import read_csv
from sklearn.model_selection import train_test_split
from sklearn.linear_model import LogisticRegression
from sklearn.externals.joblib import dump
from sklearn.externals.joblib import load
filename = 'pima-indians-diabetes.data.csv'
names = ['preg', 'plas', 'pres', 'skin', 'test', 'mass', 'pedi', 'age',
'class']
dataframe = read_csv(filename, names=names)
array = dataframe.values
X = array[:,0:8]
Y = array[:,8]
X_train, X_test, Y_train, Y_test = train_test_split(X, Y, test_size=0.33,
random_state=7)
#Fit the model on 33%
model = LogisticRegression(solver= 'liblinear')
model.fit(X_train, Y_train)
```

# Example (continued)

```
#save the model to disk
filename = 'Finalized_model.sav'
dump(model, filename)

#some time later...

#load the model from disk
loaded_model = load(filename)
result = loaded_model.score(X_test, Y_test)
print(result)
```

# Example Output

0.755905511811

# Tips for Finalizing Your Model

- Python Version
- Library Versions
- Manual Serialization