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## 4 Types of Classification Tasks in Machine Learning

by Jason Brownlee on April 8, 2020 in [Python Machine Learning](#)



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Machine learning is a field of study and is concerned with algorithms that learn from examples.

Classification is a task that requires the use of machine learning algorithms that learn how to assign a class label to examples from the problem domain. An easy to understand example is classifying emails as “spam” or “not spam.”

There are many different types of classification tasks that you may encounter in machine learning and specialized approaches to modeling that may be used for each.

### Loving the Tutorials?

In this tutorial, you will discover different types of classification predictive modeling in machine learning. The [Machine Learning with Python EBook](#) is

where you'll find the **Really Good** stuff.

After completing this tutorial, you will know:

[>> SEE WHAT'S INSIDE](#)

- Classification predictive modeling involves assigning a class label to input examples.
- Binary classification refers to predicting one of two classes and multi-class classification involves predicting one of more than two classes.
- Multi-label classification involves predicting one or more class labels for a single example. Multi-class classification refers to classification tasks where there are more than two classes.

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Types of Classification in Machine Learning  
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**Tutorial Overview**  
Save and Load Machine Learning Models in Python with scikit-learn

This tutorial is divided into five parts; they are:

1. Classification Predictive Modeling
2. Binary Classification
3. Multi-Class Classification  
The [Machine Learning with Python EBook](#) is where you'll find the **Really Good** stuff.
4. Multi-Label Classification
5. Imba    [>> SEE WHAT'S INSIDE](#)

## Classification Predictive Modeling

In machine learning, **classification** refers to a predictive task for a given example of input data.

Examples of classification problems include:

- Given an example, classify if it is spam or not.
- Given a handwritten character, classify it as one character.
- Given recent user behavior, classify as churn or not.

From a modeling perspective, classification requires a set of outputs from which to learn.

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A model will use the training dataset and will calculate how to best map examples of input data to specific class labels. As such, the training dataset must be sufficiently representative of the problem and have many examples of each class label.



Class labels are often string values, e.g. “spam,” “not spam,” and must be mapped to numeric values

**Picked for you** provided to an algorithm for modeling. This is often referred to as **label encoding**, where a unique integer is assigned to each class label, e.g. “spam” = 0, “no spam” = 1.



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There are many different types of classification algorithms for modeling classification predictive modeling problems.



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There is no good theory on how to map algorithms onto problem types; instead, it is generally recommended that a practitioner use controlled experiments and discover which algorithm and algorithm configuration results in the best performance for a given classification task.



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Classification predictive modeling algorithms are evaluated based on their results. Classification accuracy is a popular metric used to evaluate the performance of a model based on the predicted class labels.

Classification accuracy is not perfect but is a good starting point for many classification tasks.



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of class labels, some tasks may require the prediction of a **probability of class membership** for each example. This provides additional uncertainty in the prediction that an application or user can then interpret. A popular diagnostic for evaluating predicted probabilities is the **ROC Curve**.



Save and Load Machine Learning Models

are perhaps four main types of classification tasks that you may encounter; they are:

- Binary Classification
- Multi-Class Classification
- Multi-Label Classification
- Imbalanced Classification

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Let's take a closer look at each in turn.

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## Binary Classification

Binary classification refers to those classification tasks that have two class labels.

Examples include:

- Email spam detection (spam or not).
- Churn prediction (churn or not).
- Conversion prediction (buy or not).

Typically, binary classification tasks involve one class abnormal state.

For example “not spam” is the normal state and “spam not detected” is the normal state of a task that involves

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abnormal state.

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The class for the normal state is assigned the class label 0 and the class with the abnormal state is assigned the class label 1.

It is common to model a binary classification task with a model that predicts a Bernoulli probability distribution for each example.

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a discrete probability distribution that covers a case where an event will have a binary outcome as either a 0 or 1. For classification, this means that the model predicts a probability of an example belonging to class 1, or the abnormal state.

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Popular algorithms that can be used for binary classification include:

- Logistic Regression

 Feature Selection For Machine Learning in Python Decision Trees

- Support Vector Machine

 Naive Bayes Python Machine Learning Mini-Course

These algorithms are specifically designed for binary classification and do not natively support more than two classes; examples include Logistic Regression and Support Vector Machines.

 Save and Load Machine Learning Models  
It's take a closer look at a dataset to develop an intuition for binary classification problems. in Python with scikit-learn

We can use the `make_blobs()` function to generate a synthetic binary classification dataset.

The example below generates a dataset with 1,000 examples that belong to one of two classes, each with two input features.

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```

1 # where you'll find the Really Good stuff
2 from numpy import where
3 from collections import Counter
4 from sklearn.datasets import make_blobs
5 from matplotlib import pyplot
6 # define dataset
7 X, y = make_blobs(n_samples=1000, centers=2, random_state=1)
8 # summarize dataset shape
9 print(X.shape, y.shape)
10 # summarize observations by class label
11 counter = Counter(y)
12 print(counter)
13 # summarize first few examples
14 for i in range(10):
15     print(X[i], y[i])
16 # plot the dataset and color the by class label
17 for label, _ in counter.items():
18     row_ix = where(y == label)[0]
19     pyplot.scatter(X[row_ix, 0], X[row_ix, 1],
20 pyplot.legend()
21 pyplot.show()
```

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Running the example first summarizes the created dataset showing the 1,000 examples divided into input ( $X$ ) and output ( $y$ ) elements.



The distribution of the class labels is then summarized, showing that instances belong to either class 0 or class 1 and that there are 500 examples in each class.

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Next, the first 10 examples in the dataset are summarized, showing the input values are numeric and the target values are categorical indicating the class membership.



#### Python Step-By-Step

```

1 (1000, 2) (1000,)
2
3 Counter({0: 500, 1: 500}) ...
4
5 [-3.0583727212e+48825769] 0
6 [-8.60973869 -3.72714879] 1
7 [1.37129721 5.23107449] 0
8 [-9.33917563 -2.9544469] 1
9 [11.52178593 8.5275513] 1
10 [-11.42257341 -4.85679127] 1
11 [-10.44518578 -3.76476563] 1
12 [-10.44603561 -3.26065964] 1
13 [-0.61947075 3.48804983] 0
14 [-10.91115591 -4.5772537] 1

```



a scatter plot is created for the input variables in the dataset and the points are colored based on their class value.



#### Save and Load Machine Learning Models

see two distinct clusters that we might expect would be easy to discriminate.  
in Python with scikit-learn

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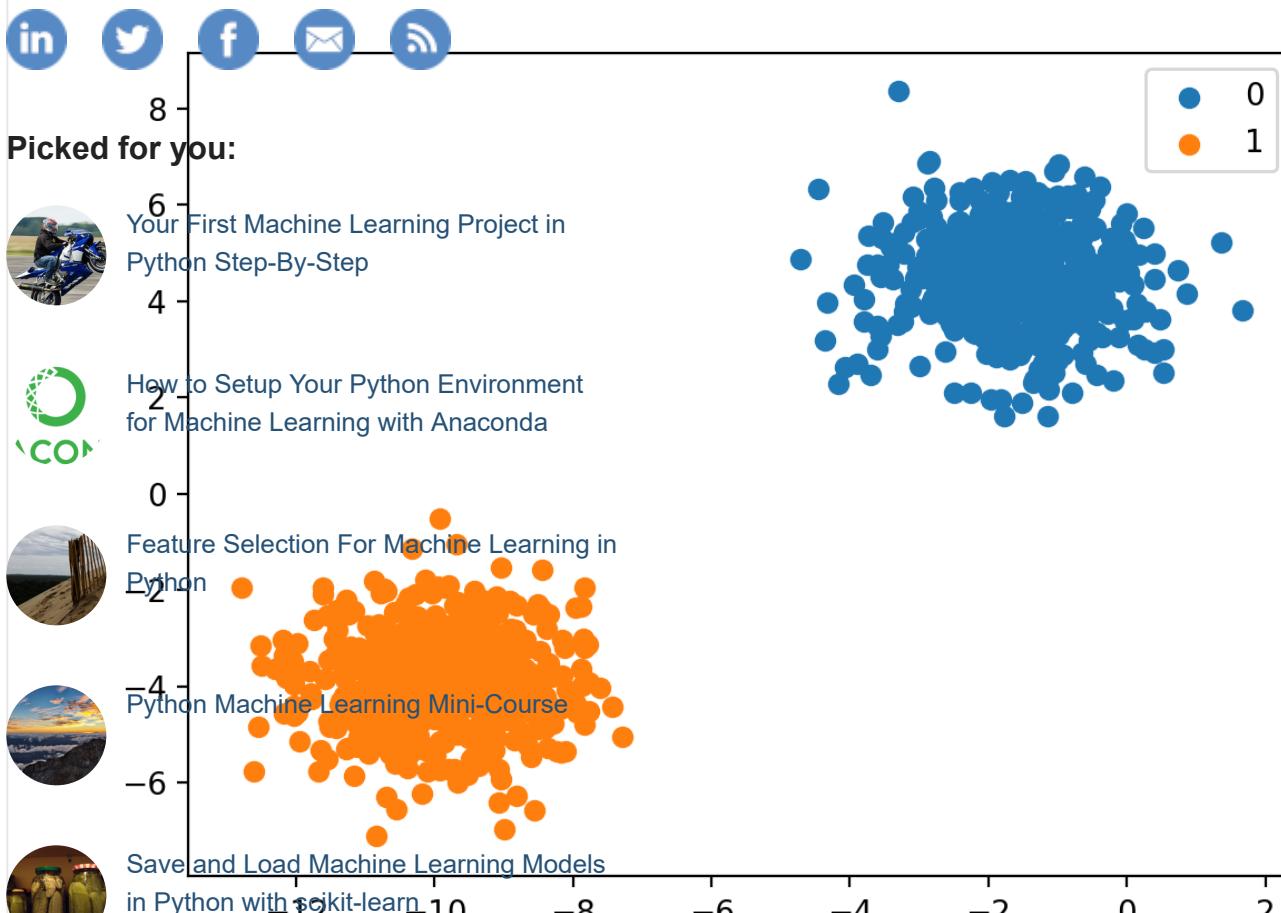
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## Never miss a tutorial:



Scatter Plot of Binary Classification Dataset

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## Multi-Class Classification

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Multi-class classification refers to those classification tasks that have more than two class labels.

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Examples include:

- Face classification.
- Plant species classification.
- Optical character recognition.

Unlike binary classification, multi-class classification deals with more than two outcomes. Instead, examples are classified as belonging to one of several categories.

The number of class labels may be very large on some occasions, such as predicting the species of a flower from a photo as belonging to one among thousands or tens of thousands of species.

Problems that involve predicting a sequence of words from a text document, such as sentiment analysis, are also considered a special type of multi-class classification.

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**Never miss a tutorial:** involves a multi-class classification where the size of the vocabulary defines the number of possible classes that may be predicted and could be tens or hundreds of thousands of words in size.

 In common to model a multi-class classification task with a model that predicts a **Multinoulli probability distribution** for each example.

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The Multinoulli distribution is a discrete probability distribution that covers a case where an event will have  **multiple outcomes**, e.g. learning {0, 1, 2, ..., K}. For classification, this means that the model predicts the probability of an example belonging to each class label.

Many algorithms used for binary classification can be used for multi-class classification.

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- k-Nearest Neighbors.

 [Feature Selection For Machine Learning in Python](#)  
Naive Bayes.

- Random Forest.

 [Gradient Boosting](#)  
[Python Machine Learning Mini-Course](#)

Algorithms that are designed for binary classification can be adapted for use for multi-class problems.

This involves using a strategy of fitting multiple binary classification models for each class vs. all other classes (called one-vs-rest) or one model for each pair of classes (called one-vs-one).



- **One-vs-Rest:** Fit one binary classification model for each class vs. all other classes.
- **One-vs-One:** Fit one binary classification model for each pair of classes.

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Binary classification algorithms that can use these strategies for multi-class classification include:

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- [Logistic Regression](#) finds the **Really Good** stuff.
- [Support Vector Machine](#)

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Next, let's take a closer look at a dataset to develop an intuition for multi-class classification problems.

We can use the `make_blobs()` function to generate a synthetic multi-class classification dataset.

The example below generates a dataset with 1,000 examples with two input features.

```
1 # example of multi-class classification task
2 from numpy import where
3 from collections import Counter
4 from sklearn.datasets import make_blobs
5 from matplotlib import pyplot
6 # define dataset
7 X, y = make_blobs(n_samples=1000, centers=3,
8 # summarize dataset shape
9 print(X.shape, y.shape)
10 # summarize observations by class label
```

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```

11 counter = Counter(y)
12 print(counter)
13 # summarize first few examples
14 for i in range(10):
15     print(X[i], y[i])
16 # plot the dataset and color the by class label
17 for label, _ in counter.items():
18     row_ix = where(y == label)[0]
19     pyplot.scatter(X[row_ix, 0], X[row_ix, 1], label=str(label))
20 pyplot.legend()
21 pyplot.show()

```

### Python Step-By-Step

Running the example first summarizes the created dataset showing the 1,000 examples divided into input ( $X$ ) and output ( $y$ ) elements.

### How to Setup Your Python Environment

The distribution of the class labels is then summarized, showing that instances belong to class 0, class 1,

or class 2 and that there are approximately 333 examples in each class.

Next, the first 10 examples in the dataset are summarized showing the input values are numeric and the output are integers that represent the class membership.

```

1 (1000, 2) (1000,)
2
3 Counter({0: 334, 1: 333, 2: 333})
4
5 [-3.05837272  4.48825769] 0
6 [-8.60973869 -3.72714879] 1
7 [1.37129721  5.23107449] 0
8 [-9.33917563 -2.9544469 ] 1
9 [-8.63895561 -8.05263469] 2
10 [-8.48974309 -9.05667083] 2
11 [-7.51235546 -7.96464519] 2
12 [-7.51320529 -7.46053919] 2
13 [-0.61947075  3.48804983] 0
14 [-10.91115591 -4.5772537 ] 1

```

Finally, a scatter plot is created for the input variables in the dataset and the points are colored based on their class value.

We can see what's inside that we might expect would be easy to discriminate.

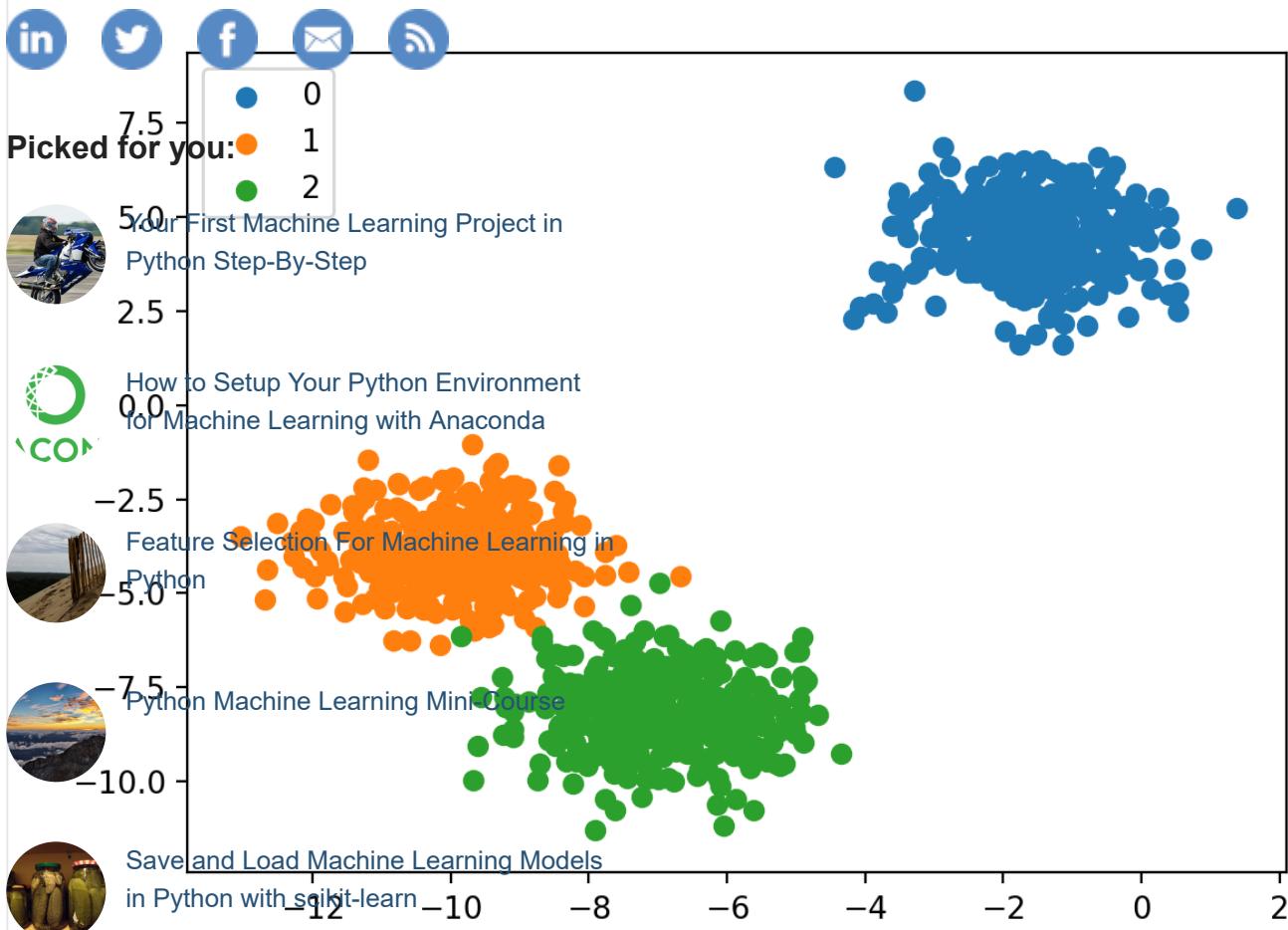
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Scatter Plot of Multi-Class Classification Dataset

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## Multi-Label Classification

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where you'll find the **Really Good** stuff.

**Multi-label classification** refers to those classification tasks that have two or more class labels, where one or more classes are predicted for each example.

Consider the example of **photo classification**, where a given photo may have multiple objects in the scene and a model may predict the presence of multiple known objects in the photo, such as “*bicycle*,” “*apple*,” “*person*,” etc.

This is unlike binary classification and multi-class classification, where one class is predicted for each example.

It is common to model multi-label classification tasks with a vector output taking predicted as a Bernoulli probability distribution, which outputs multiple binary classification predictions for each example.

Classification algorithms used for binary or multi-class classification. Specialized versions of standard classification algorithms can be used for multi-label classification.

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versions of the algorithms, including:

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- Multi-label Gradient Boosting

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Another approach is to use a separate classification algorithm to predict the labels for each class.



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Take a closer look at a dataset to develop an intuition for multi-label classification problems.

We can use the `make_multilabel_classification()` function to generate a synthetic multi-label classification dataset. How to Setup Your Python Environment



for Machine Learning with Anaconda

The example below generates a dataset with 1,000 examples, each with two input features. There are three classes, each of which may take on one of two labels (0 or 1).



Feature Selection For Machine Learning in

```
1 # example of a multi-label classification task
2 from sklearn.datasets import make_multilabel_classification
3 # define dataset
4 X, y = make_multilabel_classification(n_samples=1000, n_features=2, n_classes=3, n_labels=2, random_state=1)
5 # summarize dataset shape
6 print(X.shape, y.shape)
7 # summarize first few examples
8 for i in range(10):
9     print(X[i], y[i])
```



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Using the example first summarizes the created dataset showing the 1,000 examples divided into input

and output (`y`) elements.

Next, the first 10 examples in the dataset are summarized showing the input values are numeric and the target values are integers. They represent the class label membership.

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```
1 The Machine Learning with Python EBook is
2 (1000, 2) (1000, 3)
3 [18. 35.] [1 1 1]
4 [22. 33.] [1 1 1]
5 [26. 36.] [1 1 1]
6 [24. 28.] [1 1 0]
7 [23. 27.] [1 1 0]
8 [15. 31.] [0 1 0]
9 [20. 37.] [0 1 0]
10 [18. 31.] [1 1 1]
11 [29. 27.] [1 0 0]
12 [29. 28.] [1 1 0]
```

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## Imbalanced Classification

Imbalanced classification refers to classification tasks where the classes are not equally distributed.

Typically, imbalanced classification tasks are binary classification problems where most of the training dataset belong to the normal class and a small number of examples belong to the minority class.

Examples include:

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- Medical diagnostic tests.

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These problems are modeled as binary classification tasks, although may require specialized techniques.



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Specialized techniques may be used to change the composition of samples in the training dataset by undersampling the majority class or oversampling the minority class.

Examples include:

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Random Undersampling.

- SMOTE Oversampling.



Feature Selection For Machine Learning in Python  
Specialized modeling algorithms may be used that pay more attention to the minority class when fitting the model on the training dataset, such as cost-sensitive machine learning algorithms.

Examples include:



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### Cost-sensitive Logistic Regression.

- Cost-sensitive Decision Trees.

### Save and Load Machine Learning Models



### Cost-sensitive Support Vector Machines in Python with scikit-learn

Finally, alternative performance metrics may be required as reporting the classification accuracy may be misleading.

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Examples include:

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- Precision where you'll find the **Really Good** stuff.
- Recall.
- F-Me >> SEE WHAT'S INSIDE

Next, let's take a closer look at a dataset to develop an intuition for imbalanced classification problems.

We can use the `make_classification()` function to generate a dataset.

The example below generates a dataset with 1,000 examples and two input features.

```
1 # example of an imbalanced binary classification problem
2 from numpy import where
3 from collections import Counter
4 from sklearn.datasets import make_classification
5 from matplotlib import pyplot
6 # define dataset
7 X, y = make_classification(n_samples=1000, n_features=2, n_classes=2, n_clusters=2, weights=[0.9, 0.1], random_state=1)
8 # summarize dataset shape
```

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```

9 print(X.shape, y.shape)
10 # summarize observations by class label
11 counter = Counter(y)
12 print(counter)
13 # summarize first few examples
14 for i in range(10):
15     print(X[i], y[i])
16 # plot the dataset and color the by class label
17 for label, _ in counter.items():
18     row_ix = where(y == label)[0]
19     pyplot.scatter(X[0], X[1], c=y[0], label=str(label))
20 pyplot.legend()
21 pyplot.show()

```

Running the example first summarizes the created dataset showing the 1,000 examples divided into input

 How to Setup Your Python Environment  
for Machine Learning with Anaconda

The distribution of the class labels is then summarized, showing the severe class imbalance with about 980 examples belonging to class 0 and about 20 examples belonging to class 1.

 Feature Selection For Machine Learning in

 The first 10 examples in the dataset are summarized showing the input values are numeric and the target values are integers that represent the class membership. In this case, we can see that most examples belong to class 0, as we expect.  
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```

1 (1000, 2) (1000,)
2
3 Counter({0: 983, 1: 17})
4
5 [0 86924745 1.18613612] 0
6 [1.55110839 1.81032905] 0
7 [1.29361936 1.01094607] 0
8 [1.11988947 1.63251786] 0
9 [1.04235568 1.12152929] 0
10 [1.18114858 0.92397607] 0
11 [1.1365902 1.1652111] 0
12 [0.46291729 0.72924998] 0
13 [0.18315826 1.07141766] 0
14 [0.32411648 0.53515376] 0

```

Finally, a    the input variables in the dataset and the points are colored based on their class.

We can see one main cluster for examples that belong to class 0 and a few scattered examples that belong to class 1. The intuition is that datasets with this property of imbalanced class labels are more challenging to model.

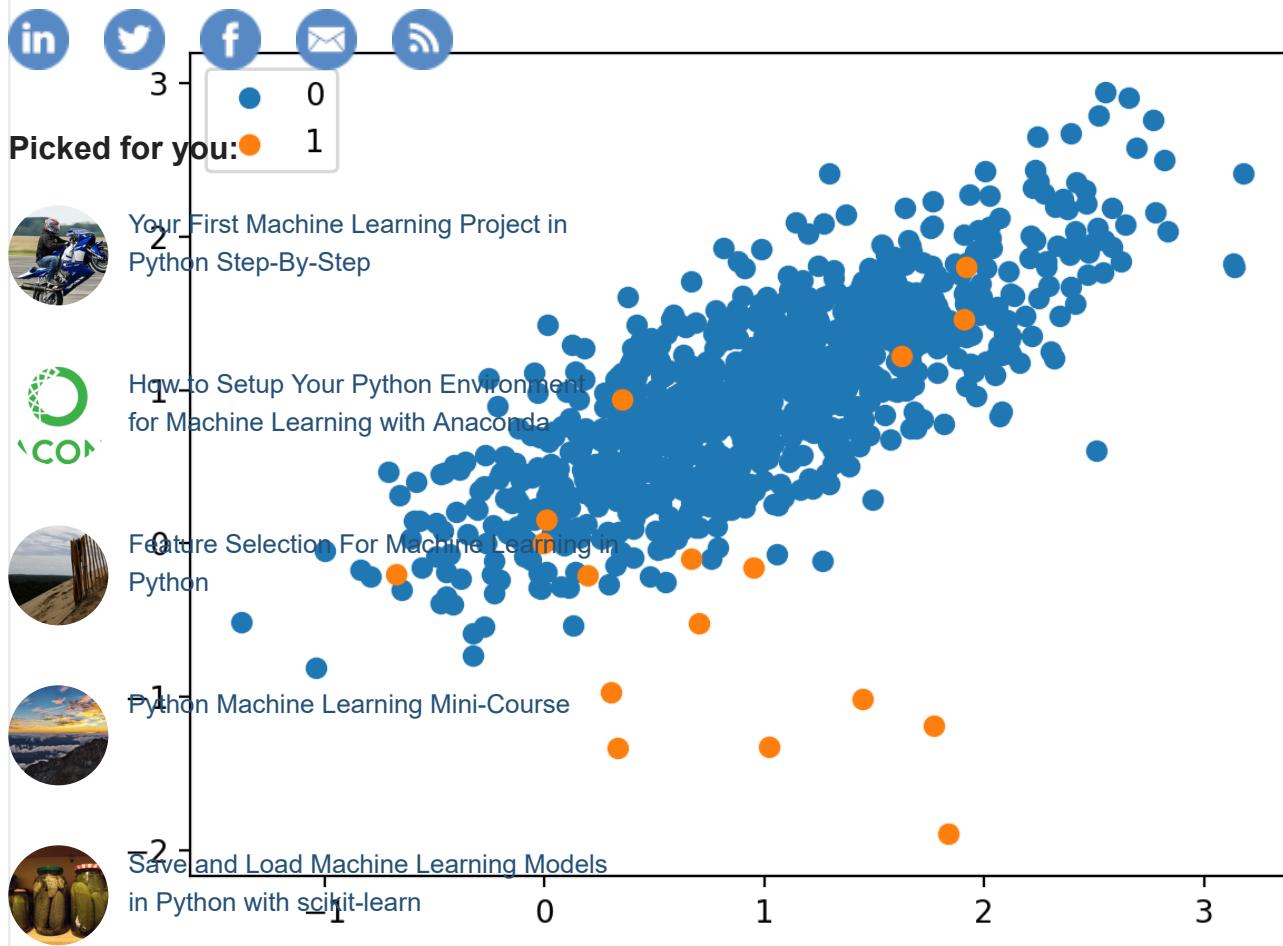
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Scatter Plot of Imbalanced Binary Classification Dataset

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## Further Reading

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This section provides more resources on the topic if you are looking to go deeper.

>> SEE WHAT'S INSIDE

- [Statistical classification](#), [Wikipedia](#).
- [Binary classification](#), [Wikipedia](#).
- [Multiclass classification](#), [Wikipedia](#).
- [Multi-label classification](#), [Wikipedia](#).
- [Multiclass and multilabel algorithms](#), [scikit-learn API](#)

## Summary

In this tutorial, you discovered different types of classification predictive modeling.

Specifically, you learned:

- Classification predictive modeling involves assigning labels to data points.

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• Binary classification refers to predicting one of two classes and multi-class classification involves **Never miss a tutorial:** predicting one of more than two classes.

 Multi-label classification involves predicting one or more classes for each example and imbalanced classification refers to classification tasks where the distribution of examples across the classes is not equal.

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### Do you have any questions?

 Ask your questions in the comments below and I will do my best to answer.

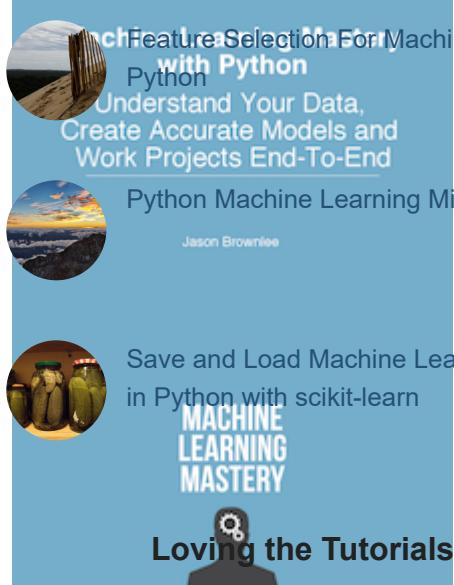
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Understand Your Data,  
Create Accurate Models and  
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### About Jason Brownlee

Jason Brownlee, PhD is a machine learning specialist who teaches developers how to get results with modern machine learning methods via hands-on projects.

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< 10 Clustering Algorithms With Python

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67 Responses to 4 Types of Classification Tasks in Machine Learning

**Never miss a tutorial:**

Rahul S Y April 9, 2020 at 2:18 am #

REPLY ↗

**Picked for you:**

Jason Brownlee April 9, 2020 at 8:06 am #

REPLY ↗

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Thanks!

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Samit Mandol August 7, 2020 at 2:25 pm #

REPLY ↗

Sir  
Feature Selection For Machine Learning in Python  
Thank you for explaining it so clearly which is easy to understand.Regards  
Python Machine Learning Mini-Course

Shaheen Mohammed Saleh April 10, 2020 at 6:39 am #

REPLY ↗

Save and Load Machine Learning Models  
Dear Jason May God Bless you is there any way for extracting formula or equation from univariate many variables regression using machine learning**Loving the Tutorials?**Jason Brownlee April 10, 2020 at 8:36 am #  
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REPLY ↗

where you'll find the **Really Good** stuff.  
We can use a model to infer a formula, not extract one.

ML &gt;&gt; SEE WHAT'S INSIDE regression model.



Skylar May 18, 2020 at 1:46 pm #

Hi Jason,

To follow up your answer to this question, I have ML that is applied on regression problems and sometimes, your answers will be highly appreci

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Jason Brownlee May 19, 2020 at 5

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None.

A dataset that requires a numerical prediction is a regression problem.  
 An algorithm that fits on a regression dataset is a regression algorithm.

A model fit using a regression algorithm is a regression model.

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Does that help?



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**Skylar** May 19, 2020 at 9:37 am #

How to Setup Your Python Environment for Machine Learning



Feature Selection For Machine Learning in Python



**Jason Brownlee** May 19, 2020 at 1:25 pm #

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Sorry, I don't have tutorials on the topic.



Save and Load Machine Learning Models

in Python with scikit-learn

**shameen mohammed saleh** April 10, 2020 at 5:56 pm #

REPLY ↗

Sorry Jason I Forget to tell you I mean Non linear regression using python Thankyou very much

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**Jason Brownlee** April 11, 2020 at 6:11 am #

REPLY ↗

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**Han Ki Cheol** April 10, 2020 at 1:48 pm #

REPLY ↗

Thank you!

very useful article to me.

**Jason Brownlee** April 10, 2020 at 3:33 pm #

I'm happy to hear that!

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**Never miss Shatutor** **Sankar Panda** April 13, 2020 at 4:08 pm #

REPLY ↗



### Picked for you:



**Jason Brownlee** April 14, 2020 at 6:04 am #

REPLY ↗

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How to Setup Your Python Environment for Machine Learning with Anaconda

RK April 14, 2020 at 8:12 pm #

REPLY ↗

Very nicely structured ! Thanks for this.



Feature Selection For Machine Learning in Python



**Jason Brownlee** April 15, 2020 at 7:59 am #

REPLY ↗

Python Machine Learning Mini-Course

Thanks!



Save and Load Machine Learning Models in Python with scikit-learn

Jens April 17, 2020 at 10:10 pm #

REPLY ↗

Hi Jason,

I have a classification problem, i.e. refining the results of the algorithm. Essentially, my KNN classification algorithm delivers a fine result of a list of articles in a csv file that I want to work with. Those classified with a 'yes' are relevant, those with 'no' are not.

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I use a euclidean distance and get a list of items. The final result delivers a list of 10 (or whatever k-value I apply). >> SEE WHAT'S INSIDE e as a rank.

#### QUESTION:

How can best project a list of relevant items to proceed with? – i.e. how do I potentially loop the first list results of perhaps 8 yes and 2 no (when k=10)?

I guess I won't have to pre-process text again as well as a k=998 (corresponding to the total list of entries in the dataset) carrying a 'no'. That would keep the distance unaffected. I had to train data once again, and I am not sure how to

Thx, Jens

**Jens** April 17, 2020 at 10:13 pm #

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## A typo sneaked in... Never miss a tutorial:

I did try simply to run a k=998 (correponding to the total list of entries in the data load) remove all, and then remove all the articles carrying a 'no'. Should say:

I did try simply to run a k=998 (correponding to the total list of entries in the data load), and then remove all the articles carrying a 'no'.

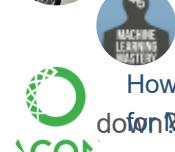
## Picked for you:



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**Jason Brownlee** April 18, 2020 at 5:55 am #

REPLY ↗



How to Setup Many Python Enthusiasts posting on stackoverflow or perhaps you can boil your question down Machine Learning with Anaconda



Feature Selection For Machine Learning in Python

**Hugo Souza** May 2, 2020 at 3:30 am #

REPLY ↗



And One class, Jason? where can we put the concept?

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**Jason Brownlee** May 2, 2020 at 5:50 am #

REPLY ↗

Save and Load Machine Learning Models

in Python

With selection (i.e. fundamentally different), otherwise binary classification.

## Loving the Tutorials?

**mp505** May 14, 2020 at 3:58 am #

REPLY ↗

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Hi Jason where you'll find the **Really Good** stuff.

Thank you for this great article! It helped me a lot.

>> SEE WHAT'S INSIDE

What kind of question Answering or specifically Span Extraction? The case where the model has to select the start and end indices within a paragraph. Is it a multi class classification? You wrote "Problems that involve predicting a sequence of words, such as text translation models, may also be considered a special type of multi-class classification. This involves a multi-class classification where the size of the sequence that may be predicted and could be tens or hundreds of extraction problems?

Thank you in advance!



**Jason Brownlee** May 14, 2020 at 5:56 am #

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X

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Question answering is sequence generation – not classification. I don't know what span extraction is.

**Never miss a tutorial:**

[https://machinelearningmastery.com/sequence-prediction-problems-learning-lstm-recurrent-neural-](https://machinelearningmastery.com/sequence-prediction-problems-learning-lstm-recurrent-neural-networks/)



## Picked for you:

**nlp509** May 14, 2020 at 6:23 am #



Your First Machine Learning Project in Python Step By Step  
Thank you for the quick response!

REPLY ↗



The definition of span extraction is "Given the context C, which consists of n tokens, that is  $C = \{t_1, t_2, \dots, t_n\}$ , and the question Q, the span extraction task requires extracting the continuous subsequence  $A = \{t_i, t_{i+1}, \dots, t_{i+k}\}$  ( $1 \leq i \leq i+k \leq n$ ) from context C as the correct answer to question Q by learning the function F such that  $A = F(C, Q)$ ."



It's the SQuAD task. BiDAF, QANet and other models calculate a probability for each word in the given Context for being the start and end of the answer. They use the cross entropy loss which is used for classification. That's why I'm confused. I don't get what the classes in this case would be? start and end?



I don't see span extraction as a sequence generation problem? No words are predicted/generated but only the start and end calculated. Am I wrong?



Save and Load **Jason Brownlee** May 14, 2020 at 1:23 pm #  
in Python with scikit-learn  
Thanks.

REPLY ↗

## Loving the Tutorials?

**Nguyen Phan The Huy** May 15, 2020 at 11:54 pm #

REPLY ↗

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Thank you for the nice article! It helped me a lot!

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**Jason Brownlee** May 16, 2020 at 6:14 am #

REPLY ↗

You're welcome.

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**Skylar** May 18, 2020 at 2:10 pm #

Hi Jason,

Very nice post! You mentioned that some algorithms work for classification but can also be applied on multi-class classification. I have two questions about this:

- Never miss a tutorial:**
- (1) Could you elaborate a bit what does it mean with their extension? It is the modification for the algorithm itself or you mean the source code for the corresponding packages? As users, do we need to do extra things if we want to use logistic regression and SVM for multi-class classification?
  - (2) Actually I used both of logistic regression and SVM on multi-class classification, but it seems only SVM works (I was trying them in R), but it showed the error stating that logistic regression can only be used for binary classification. Is it true or maybe I did something wrong?

### Picked for you:

Thank you very much in advance!  
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  **Jason Brownlee** May 19, 2020 at 5:52 am #  
[How to Setup Your Python Environment for Machine Learning with Anaconda](#)  
 Thanks.

Often we can use a OVR to adapt binary to multi-class classification, here are examples:  
 [Feature Selection For Machine Learning in Python](#)  
<https://machinelearningmastery.com/one-vs-rest-and-one-vs-one-for-multi-class-classification/>

  **Skylar** May 19, 2020 at 9:39 am #  
 Thank you Jason!

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 **Jason Brownlee** May 19, 2020 at 1:25 pm #  
 You're welcome.  
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**Elena** May 20, 2020 at 7:26 pm #

[REPLY ↗](#)

>> SEE WHAT'S INSIDE

[REPLY ↗](#)

I would like if you could solve this question for me:  
 ... much for sharing your knowledge.

I have a dataset with chemical properties of water. Using column with the classification label: "clean water" and the presence in the water of "Calcium", "pH" and "electrical conductivity".

My question is if I can use the Classification Supervised created (clean water or not) using as input variables the ("Calcium", "pH" and "conductivity"). electrical "). Or if I haven't used to create it.

I don't know if it is possible to use supervised classification variables?

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I think Regression Supervised Learning cannot be used to predict a variable that is dependent on the others  
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 (if it was created from an equation using the other variables), is that correct?



Picked for you: **Jason Brownlee** May 21, 2020 at 6:15 am #



It sounds like classification:

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<https://machinelearningmastery.com/first-machine-learning-project-python/>  
 regression



Perhaps develop a prototype model and test whether it is possible to model the problem as classification.  
[How to Setup Your Python Environment for Machine Learning with Anaconda](#)



Feature Selection For Machine Learning in Python

**Richard O'Hara** June 8, 2020 at 1:07 am #

REPLY ↗

Jason,



Such Python Machine Learning Mini-Courses are great for accounting majors. Your examples are invaluable! Great work.



Save and Load Machine Learning Models

**Jason Brownlee** June 8, 2020 at 6:15 am #

REPLY ↗

Thanks Richard!

## Loving the Tutorials?

**John** July 1, 2020 at 9:58 pm #  
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 Good stuff, thank you

>> SEE WHAT'S INSIDE

REPLY ↗



**Jason Brownlee** July 2, 2020 at 6:20 am #

REPLY ↗

You're welcome!

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**Anthony The Koala** July 23, 2020 at 12:14 am #

Dear Dr Jason,  
 Thank you for your time.  
 Under the heading "Binary Classification", there are 20 Of particular interest is line 19:

```
1 pyplot.scatter(X[row_ix, 0], X[row_ix, 1],
```

Yes I have seen the documentation at  
**Never miss a tutorial:**  
[https://matplotlib.org/3.2.1/api/\\_as\\_gen/matplotlib.pyplot.scatter.html](https://matplotlib.org/3.2.1/api/_as_gen/matplotlib.pyplot.scatter.html)



Question please:

**Picked for you:** Why do we plot one feature of X against another feature of X? That is  $X[\text{row\_ix}, 0]$  versus  $X[\text{row\_ix}, 1]$  instead of X versus Y?



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 Now it is something obvious, but the "penny has not dropped" yet.

Or put it another way, why plot one feature against another feature?

Thank you,  
 How to Setup Your Python Environment  
 Anthony of Sydney  
 for Machine Learning with Anaconda



Feature Selection For Machine Learning in Python  
**Jason Brownlee** July 23, 2020 at 6:16 am #

REPLY ↗

A scatter plot plots one variable against another, by definition.



In Python Machine Learning Mini-Course  
 In that example we are plotting column 0 vs column 1 for each class.



Save and Load Machine Learning Models  
**Anthony The Koala** July 23, 2020 at 12:02 pm #  
 in Python with scikit-learn

REPLY ↗

Dear Dr Jason,

Thank you for the reply especially that a scatter plot is a plot of one variable against another variable, rather than an X variable against a Y variable.

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My question is: given that a plot of one variable against another variable, I would like the precise definition of what a plot of X1 (say) against X2 means versus a plot of X1 versus Y.  
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Put another way what information do get when plotting an X variable against another X variable?

>> SEE WHAT'S INSIDE X1 and X2 is?

Thank you,

Anthony of Sydney



**Jason Brownlee** July 23, 2020 at 2

A scatter plot shows the relations values change.

E.g. it can help see correlations if they bot

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Anthony The Koala July 23, 2020 at 12:37 am #

REPLY ↗



An additional question please:

**Picked for you:**  
In your examples you did plots of one feature of X versus another feature of X.

What do you do if you have more than two features and you wish to plot the one feature against the other.  
For example, there are four features in this data. Do you have to plot  $4C2 = 6$  scatter plots? If you had 10 features that is  $10C2 = 45$  plots?

Thank you,  
Anthony of Sydney, Your Python Environment  
for Machine Learning with Anaconda  




REPLY ↗

You can create multiple pair-wise scatter plots, there's an example here:

<https://machinelearningmastery.com/predictive-model-for-the-phoneme-imbalanced-classification-dataset/>  
Python Machine Learning Mini-Course



REPLY ↗

Dear Dr Jason,

First thank you. And thank you for avertting me to the scatter\_matrix at

<https://machinelearningmastery.com/predictive-model-for-the-phoneme-imbalanced-classification-dataset/>  
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I had a look at the scatter\_matrix procedure used to display multi-plots of pairwise scatter plots of where you'll find the **Really Good** stuff  
one X variable against another X variable.

>> SEE WHAT'S INSIDE on contained in multiple pairwise plots.

Question – what is your advice on interpreting multiple pairwise relationships please?

Thank you.

Anthony of Sydney



Jason Brownlee July 23, 2020 at 2

I have much on this, perhaps see  
<https://machinelearningmastery.com/mach>

And this:

<https://machinelearningmastery.com/how-t>  
between-variables/

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An Koala July 23, 2020 at 7:55 pm #

REPLY

Dear Dr Jason,

**Picked for you:** you, you're tops.

I had a further examination of scatter\_matrix from pandas.plotting import scatter\_matrix  
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Having experimented with pairwise comparisons of all features of X, the scatter\_matrix has a deficiency in that unlike pyplot's scatter, you cannot plot by class label as in the above blog.  
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```

1 data = read_csv('iris.csv',header=None)
2 X, y = (data.values)[:,0:4], (data.values)[:, -1]
3 #In case X's first column contains column names
P 4 names = X[0]
5 X = X[1:-1] ;#get rid of column names
6 X = X.astype(float); # in case the values are string.
7 #you may want to re-encode the y in case the categories are string type
8
9 #this is for future use.
10 from sklearn.preprocessing import OrdinalEncoder
11 y = reshape(y, (-1,1));#have to reshape otherwise encoder won't work properly
12 oe = OrdinalEncoder()
13 oe.fit(y)
14 y_enc = oe.transform(y); # For future use
S 15 ion with scikit-learn
in
16
17 #Preparing for scatter matrix - the scatter matrix requires a dataframe structure.
18 df = DataFrame(X,columns=names)
19 scatter_matrix(df)
20 pyplot.show(); #unfortunately the scatter_matrix will not break the plots or scatt

```



The Machine Learning with Python EBook is

where ~~you can find the really good pairwise scatter plots of variables.~~

\* scatter matrix requires as input a dataframe structure rather than a matrix.

>> SEE WHAT'S INSIDE not allow you to plot variables according to the classification labels defined in y – these are setosa, virginicum and versicolor.

Todo – using pyplot's subplots in order to display all pairwise X features displayed according to y's categories.

Thank you,

Anthony of Sydney



Jason Brownlee July 24, 2020 at 6

Yes, believe the seaborn version post on this written and scheduled.

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**Never miss a tutorial:**

Anthony The Koala July 24, 2020 at 3:17 pm #

REPLY ↗



Thank you for advising of a forthcoming post on pairwise scatter plots by class label. Look forward to that.

**Picked for you:**

I would like to have scatterplots with legends based on class label as exemplified in this page. I would like to extend this to all pairwise comparisons of X by class label.



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the Python Step By Step

phoneme-imbalanced-classification-dataset/ BUT the different colours indicating class labels don't show the class labels legend in each plot.



How to Setup Your Python Environment

Also the problem I have with scatter matrix, is if you have 4 variables of X, say variables 1,2,3,4, the for Machine Learning with Anaconda



possible pairings are (1,2), (2,1), (1,3), (3,1), (1,4), (4,1), (2,3), (3,2), (2,4), (4,2) and (3,4) and (4,3) = 12 plots.



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Python

You don't need duplicate plots. You can get the minimum plots with are (1,2), (1,3), (1,4), (2,3), (2,4),

$$\therefore = 4C_2 = 6.$$


The seaborn method at the bottom of <https://seaborn.pydata.org/generated/seaborn.scatterplot.html> confuses me with one variable label on the top, one variable label on the bottom and one variable label on the left then a legend on the right.

Thank you,



Anthony of Sydney.

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in Python with scikit-learn

Anthony The Koala July 25, 2020 at 1:23 am #

REPLY ↗

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Dear Dr Jason,

I Have Machine Learning with Python Book

which is at

where you'll find the **Really Good** stuff.

[https://seaborn.pydata.org/examples/scatterplot\\_matrix.html](https://seaborn.pydata.org/examples/scatterplot_matrix.html). It does pairwise scatter plots of X with a legend on the

&gt;&gt; SEE WHAT'S INSIDE

```

1 #Load these packages
2 import matplotlib.pyplot as plt
3 import seaborn as sns
4
5 sns.set(style='ticks')
6 #This requires an internet connection
7 df = sns.load_dataset('iris');
8
9 #Alternatively, df is a pandas.DataFrame so
10 from pandas import read_csv
11 df = read_csv('iris.csv', header=None)
12
13 # the pairplot function accepts only a Data
14 # frame, cannot have other kinds of data s
15 sns.pairplot(df hue='species');
16
17 plt.show()

```

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**Conclusions:****Never miss a tutorial:**

\* all pairwise plots of X can be achieved showing the legend by class, y. Much easier to use than scatter\_matrix and possibly easier than making your own algorithm to plot all pairwise plots of X. The pairplot function requires a DataFrame object. The DataFrame's file is a csv file, either downloaded from a server by seaborn's inbuilt load('file') where 'file' OR panda's read\_csv.

**Picked for you:** If your data is in another form such as a matrix, you can convert the matrix to a DataFrame file.

\* As a matter of my own taste, the seaborn's graphics look aesthetically more pleasing than pyplot's which your First Machine Learning Project in Python Step By Step

Again as a matter of personal tastes, I'd rather have 4C2 plots consisting of (1,2), (1,3), (1,4), (2,3), (2,4) and (3,4) than seaborn's or panda's scatter\_matrix which plot 2\*4C2 plots such as (1,2), (2,1), (1,3),(3,1), (1,4), (4,1), (2,3), (3,2), (3,4) and (4,3).

[How to Setup Your Python Environment](#)

[Thank you for Machine Learning with Anaconda](#)

Anthony of Sydney



## Feature Selection For Machine Learning in Python

**Jason Brownlee** July 25, 2020 at 6:23 am #

[REPLY ↗](#)



## Nice work Python Machine Learning Mini-Course



## Save and Load Machine Learning Models

in Python with scikit-learn

[REPLY ↗](#)

Great article! Just found a typo under the heading 'imbalanced classification': it should be oversampling the minority class.

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 **Jason Brownlee** July 27, 2020 at 5:49 am #

[REPLY ↗](#)

>> SEE WHAT'S INSIDE

**Tamesh** August 10, 2020 at 12:11 pm #

[REPLY ↗](#)

Thanks a lot

Good theoretical explanation sir

**Jason Brownlee** August 10, 2020 at 1:34 pm

Thanks!

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REPLY ↗

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Sir I that if I have a dataset which needs two classification  
I mean, if I have dataset like

Independent variables –A,

**Picked for you:**–1 and another is dependent var –2 which is dependent on dependent var –1

how can I solve this problem?  
Your First Machine Learning Project in  
Python Step By Step.  
for my bad English.

How to Setup Your Python Environment

for Machine Learning with Anaconda  
**Jason Brownlee** August 13, 2020 at 11:24 pm #

REPLY ↗

Sounds like a multi-target prediction problem.

Feature Selection For Machine Learning in

Perhaps start by modeling two separate prediction problems, one for each target.

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**yjlee** September 2, 2020 at 4:50 pm #

REPLY ↗

I want to classify the results of binary classification once again. What method should I use?

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**Jason Brownlee** September 3, 2020 at 6:03 am #

REPLY ↗

What do you mean? Classify the results of a binary classification?

If you mean feed the output of the model as input to another model, like a stacking ensemble, then this [Machine Learning With Python EBOOK](#) is [may help](#). You'll find the **Really Good** stuff.

<https://machinelearningmastery.com/stacking-ensemble-machine-learning-with-python/>

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**tet** September 21, 2020 at 2:23 pm #

REPLY ↗

Thank you for the article.

**Jason Brownlee** September 21, 2020 at 2:37

You're welcome.

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**vivek** November 6, 2020 at 6:53 pm #

Hi Jason,  
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 How can I find your book?



### Picked for you:

 **Jason Brownlee** November 7, 2020 at 6:26 am #

REPLY ↗

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 You can see the full catalog of 19 books and book bundles here:  
<http://machinelearningmastery.com/products/>

 How to Setup Your Python Environment for Machine Learning with Anaconda

**Soniya** December 24, 2020 at 10:13 pm #

REPLY ↗

 This is indeed very useful article. Thanks for sharing. Can you kindly make one such article in Python how we can apply different data oversampling and undersampling techniques, including SMOTE on text data (for example sentiment analysis dataset, binary classification)

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 **Jason Brownlee** December 25, 2020 at 5:22 am #

REPLY ↗

 Save and load Machine Learning Models in Python with scikit-learn  
 I don't think those classical methods are appropriate for text, perhaps you can check the literature for text data augmentation methods?

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 **Noy** December 31, 2020 at 7:15 am #  
 where you'll find the **Really Good** stuff.

REPLY ↗

Thanks!

Can yo >> SEE WHAT'S INSIDE visualization of the multi-label problem?

Something like a scatter plot with pie markers...



**Jason Brownlee** December 31, 2020 at 9:24 am #

No, it does not visualize well.

There is an example here that may help;  
<https://machinelearningmastery.com/multi-label-classification-tutorial/>

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 Email (will not be published) (required)


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