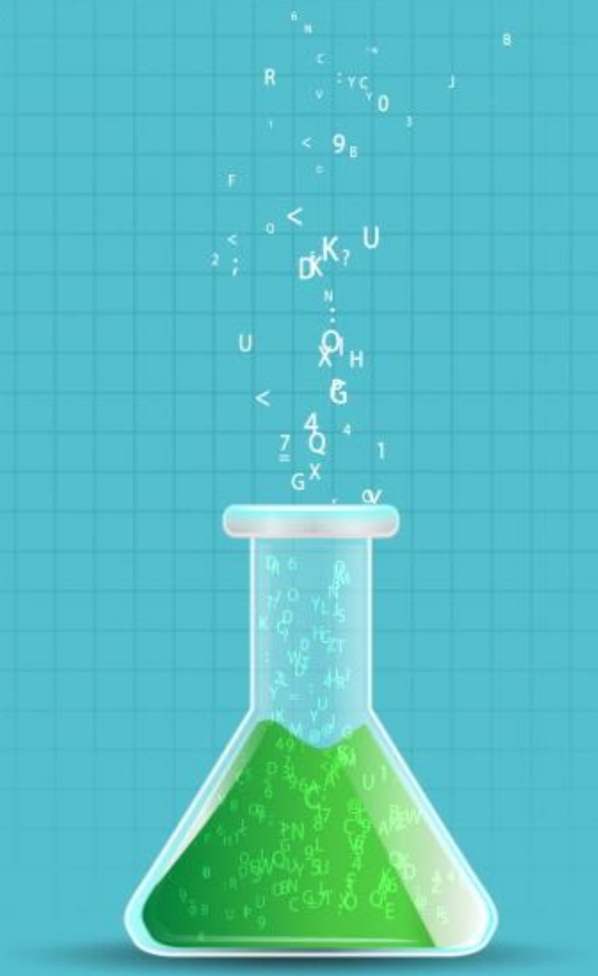
Data Science with Python

Lesson 9 — Natural Language Processing (NLP) with SciKit Learn

DATA SCIENCE

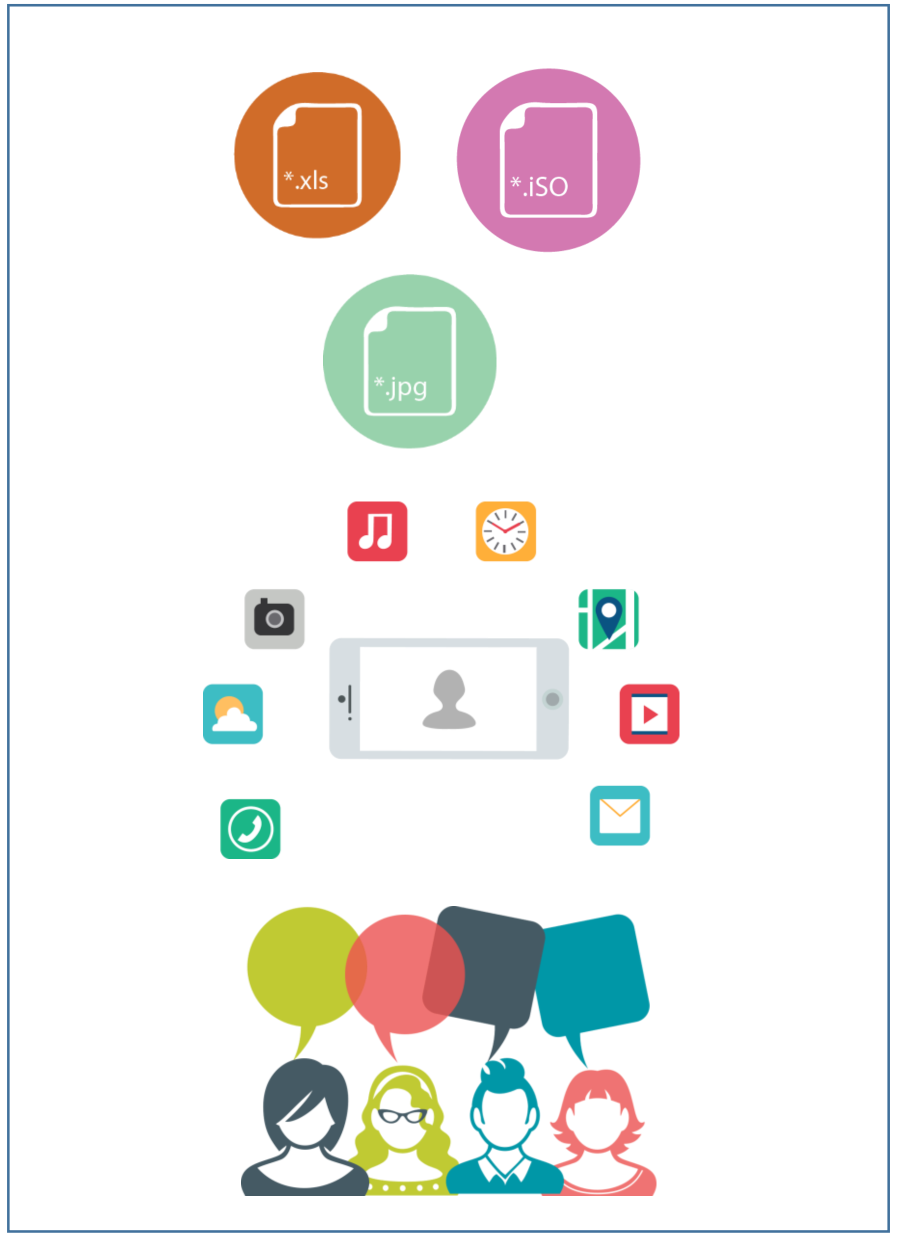
What You Will Learn

- What is Natural Language Processing
- How Natural Language Processing is helpful
- Modules to load content and category
- Applying feature extraction techniques
- Applying approaches of Natural Language Processing



Natural Language Processing (NLP)

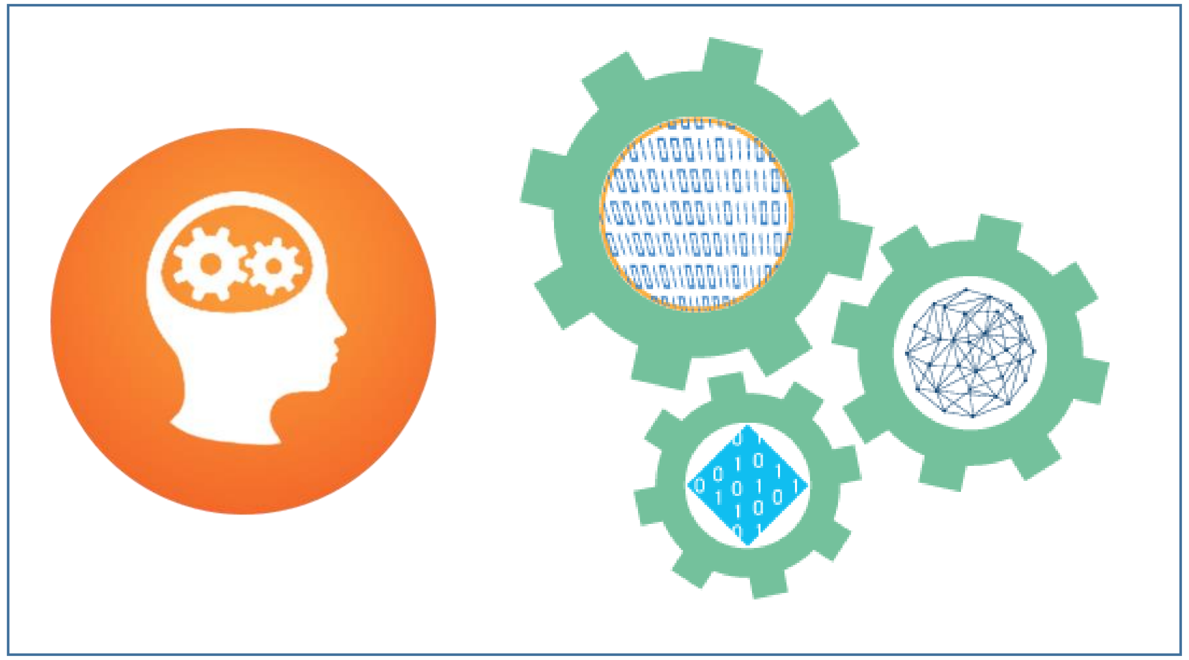
Natural language processing is an automated way to understand and analyze natural human languages and extract information from such data by applying machine algorithms.



Data from various sources

Extract information

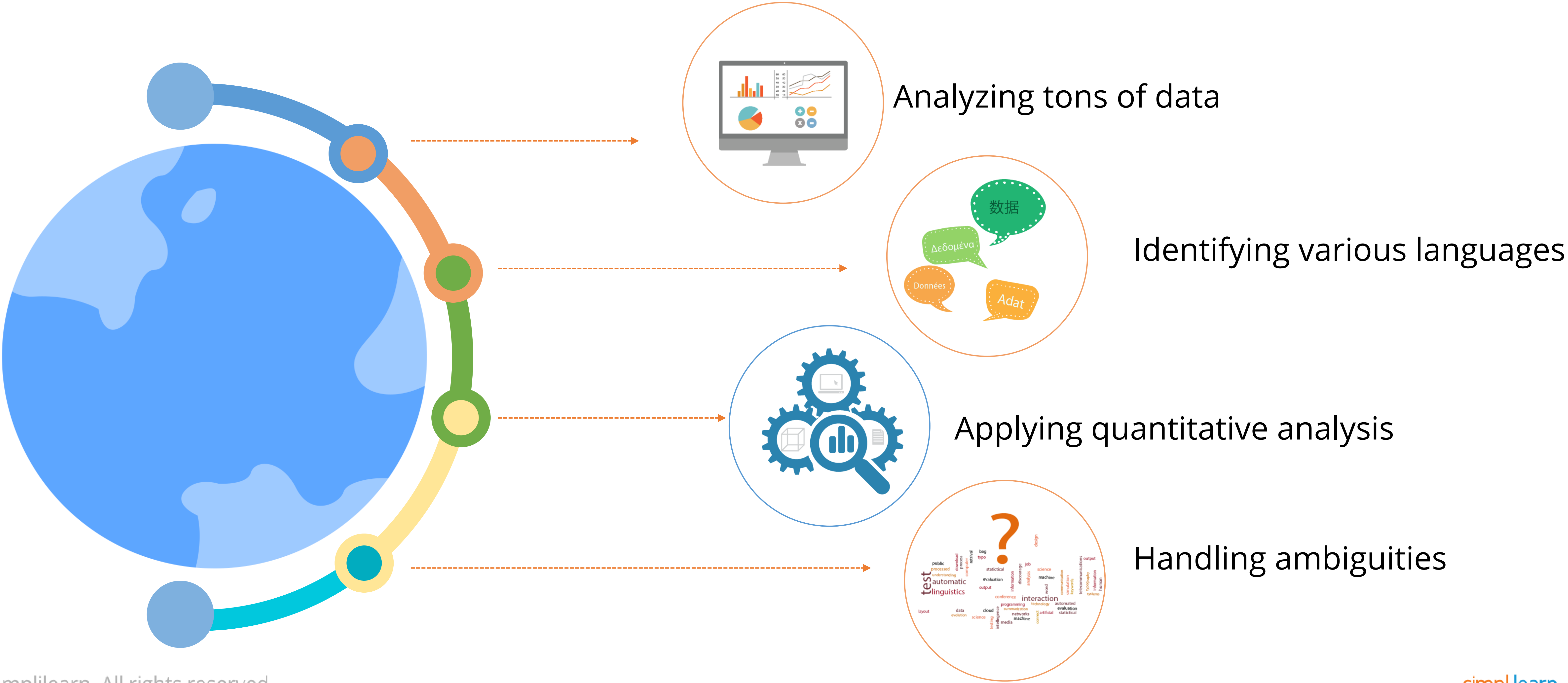
Analyze human languages



Machine algorithms and translations
(mathematics and statistics)

Why Natural Language Processing

With the advancement in technology and services, the world is now a global village. However, following are a few challenges while analyzing the huge data collection:



Analyzing tons of data

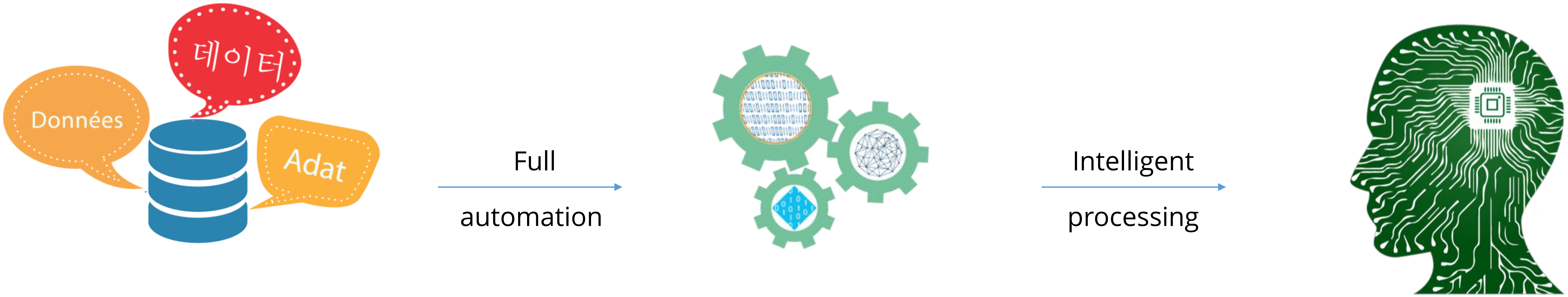
Identifying various languages

Applying quantitative analysis

Handling ambiguities

Why Natural Language Processing (contd.)

In NLP, full automation can be easily achieved by using modern software libraries, modules, and packages.



Full automation

Intelligent processing

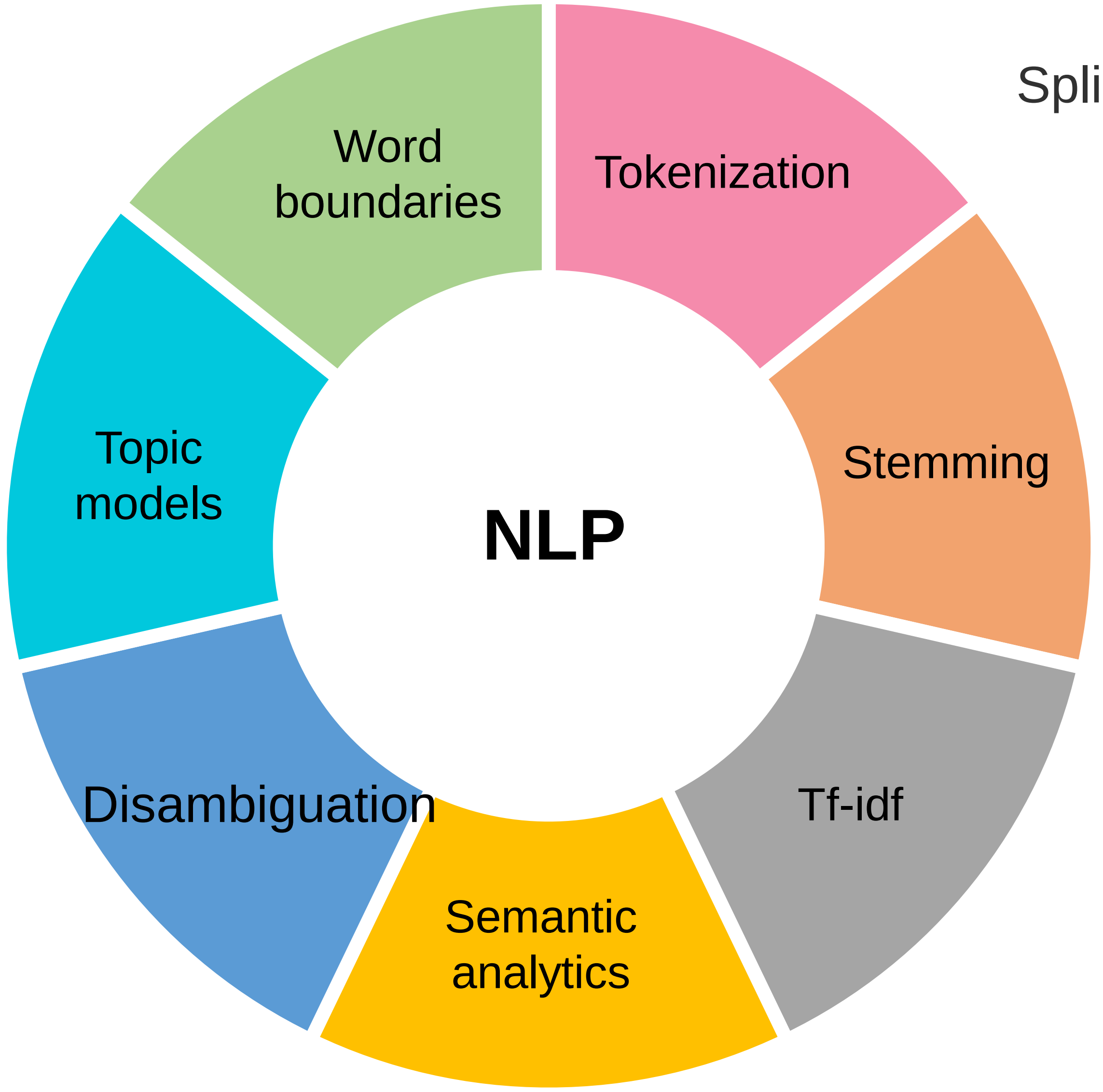
Knowledge about languages and world

Modern software libraries

Machine models

NLP Terminology

Let us understand the NLP terminologies.



NLP

Word boundaries

Determines where one word ends and the other begins

Tokenization

Splits words, phrases, and idioms

Stemming

Maps to the valid root word

Tf-idf

Represents term frequency and inverse document frequency

Semantic analytics

Compares words, phrases, and idioms in a set of documents to extract meaning

Disambiguation

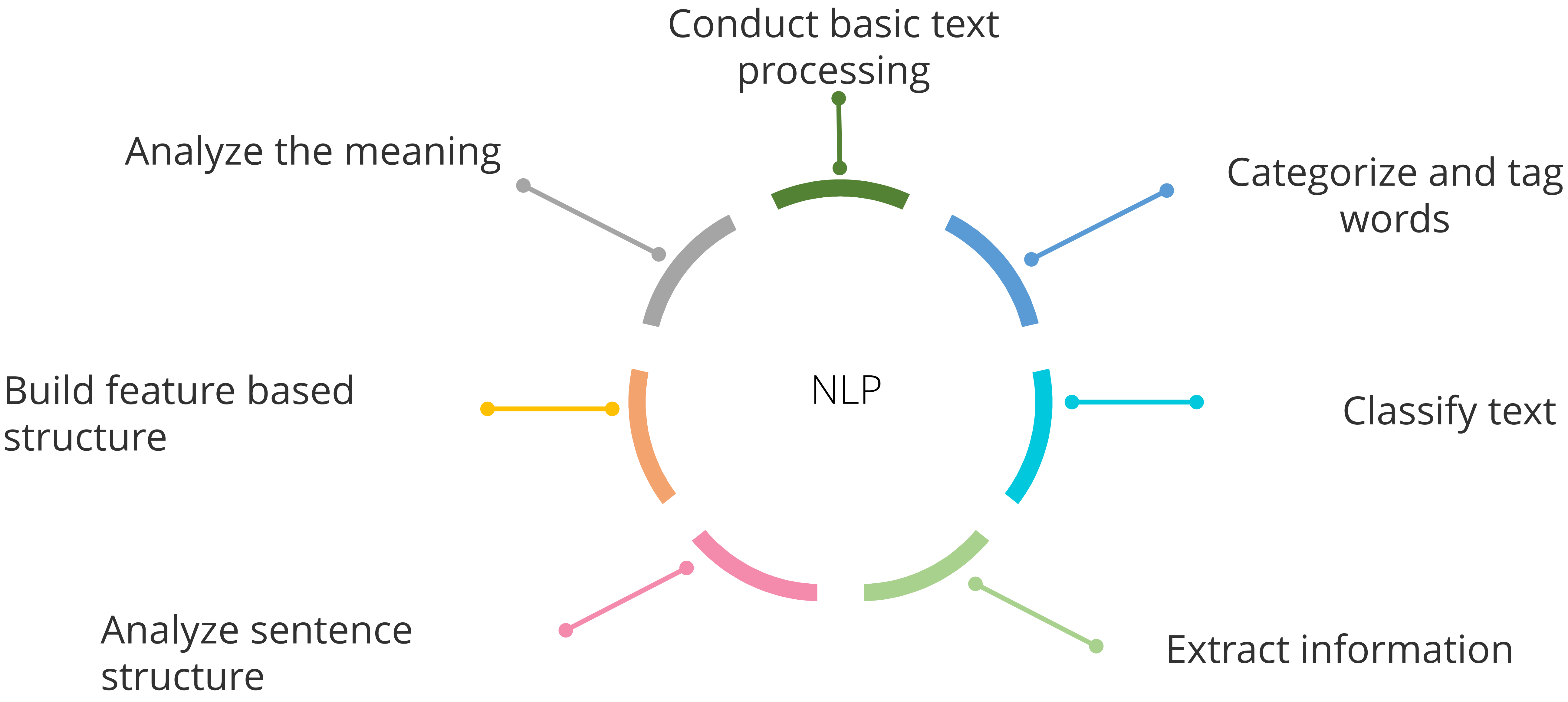
Determines meaning and sense of words (context vs. intent)

Topic models

Discover topics in a collection of documents

The NLP Approach for Text Data

Let us look at the Natural Language Processing approaches to analyze text data.



Conduct basic text processing

Categorize and tag words

Classify text

Extract information

Analyze sentence structure

Build feature based structure

Analyze the meaning

Demo 01- NLP Environmental Setup

Demonstrate the installation of NLP environment

Demo 02: Sentence Analysis

Demonstrate the sentence analysis

The NLP Applications

Let us take a look at the applications that use NLP.

Machine Translation

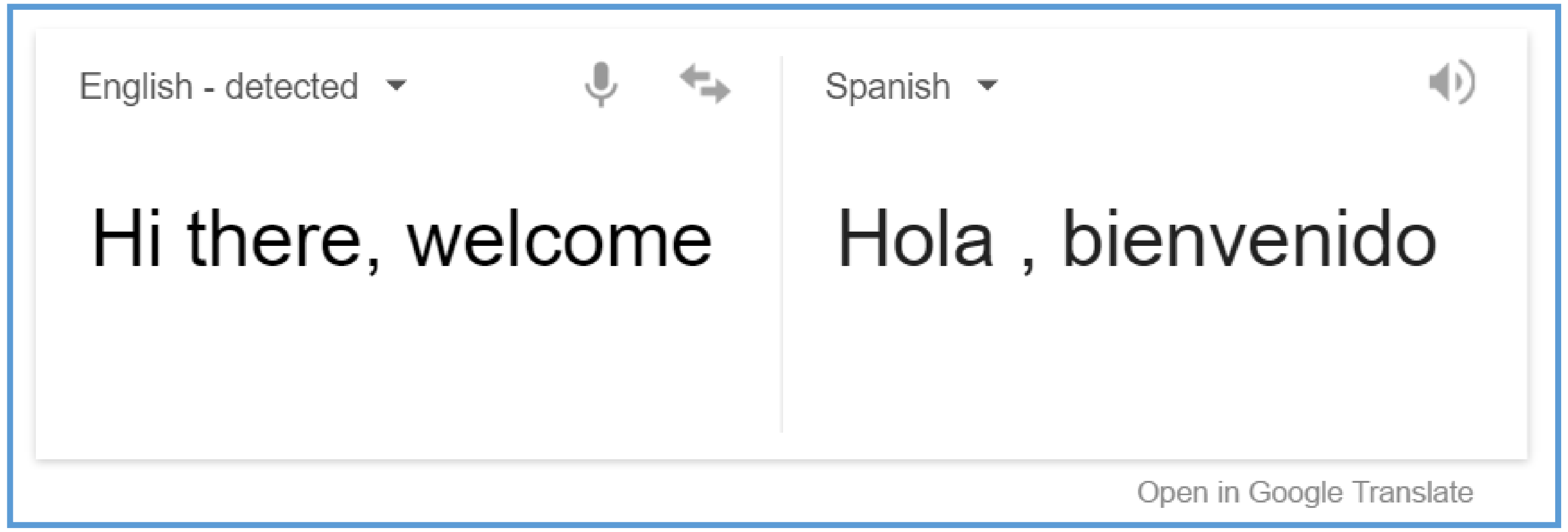
Speech Recognition

Sentiment Analysis

Machine translation is used to translate one language into another. Google Translate is an example. It uses NLP to translate the input data from one language to another.

Google Translate

Break through language barriers.



Hi there, welcome

Hola , bienvenido

The NLP Applications (contd.)

Let us take a look at the applications that use NLP

Machine Translation

Speech Recognition

Sentiment Analysis

The speech recognition application understands human speech and uses it as input information. It is useful for applications like Siri, Google Now, and Microsoft Cortana.

The NLP Applications (contd.)

Let us take a look at the applications that use NLP

Machine Translation

Speech Recognition

Sentiment Analysis

Sentiment analysis is achieved by processing tons of data received from different interfaces and sources. For example, NLP uses all social media activities to find out the popular topic of discussion.

Knowledge Check

KNOWLEDGE CHECK

In NLP, tokenization is a way to

a. Find the grammar of the text

b. Analyze the sentence structure

c. Find ambiguities

d. Split text data into words, phrases, and idioms

KNOWLEDGE CHECK

In NLP, tokenization is a way to

a. Find the grammar of the text

b. Analyze the sentence structure

c. Find ambiguities

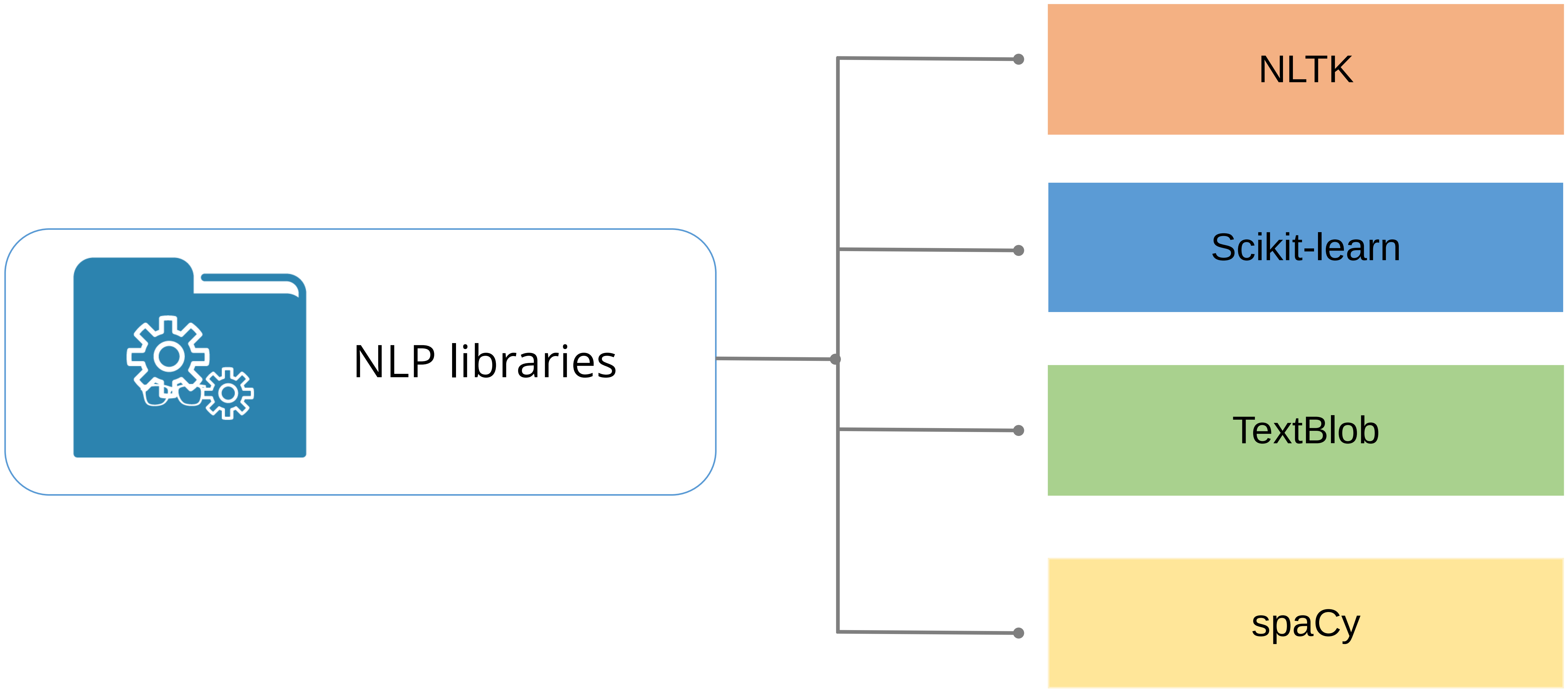
d. Split text data into words, phrases, and idioms

The correct answer is. d

Explanation: Splitting text data into words, phrases, and idioms is known as tokenization and each individual word is known as token.

Major NLP Libraries

The major NLP libraries used in Python are:



NLP libraries

NLTK

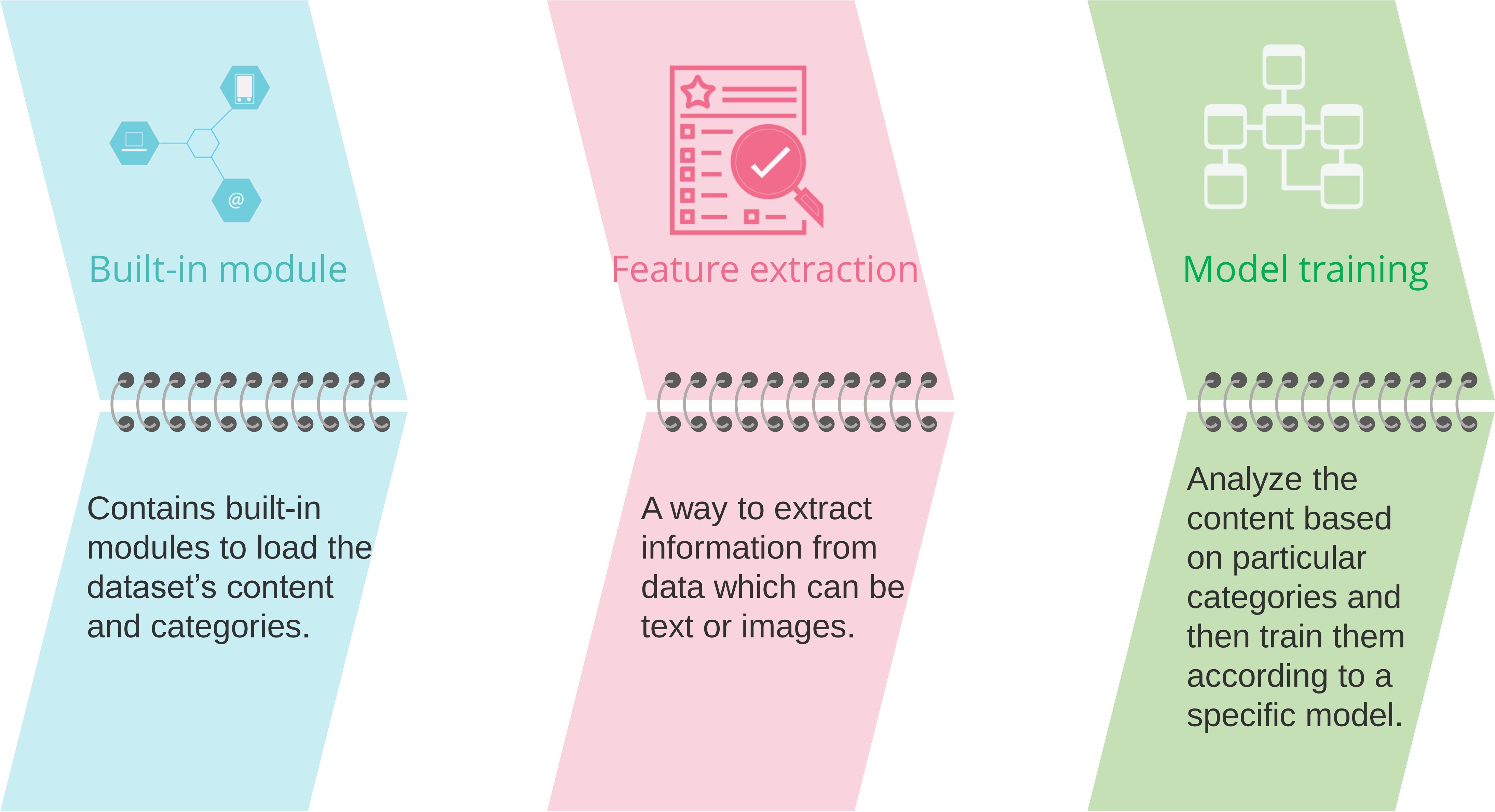
Scikit-learn

TextBlob

spaCy

The Scikit-Learn Approach

It is a very powerful library with a set of modules to process and analyze natural language data such as texts and images and extract information using machine learning algorithms.



Built-in module

Contains built-in modules to load the dataset’s content and categories.

Feature extraction

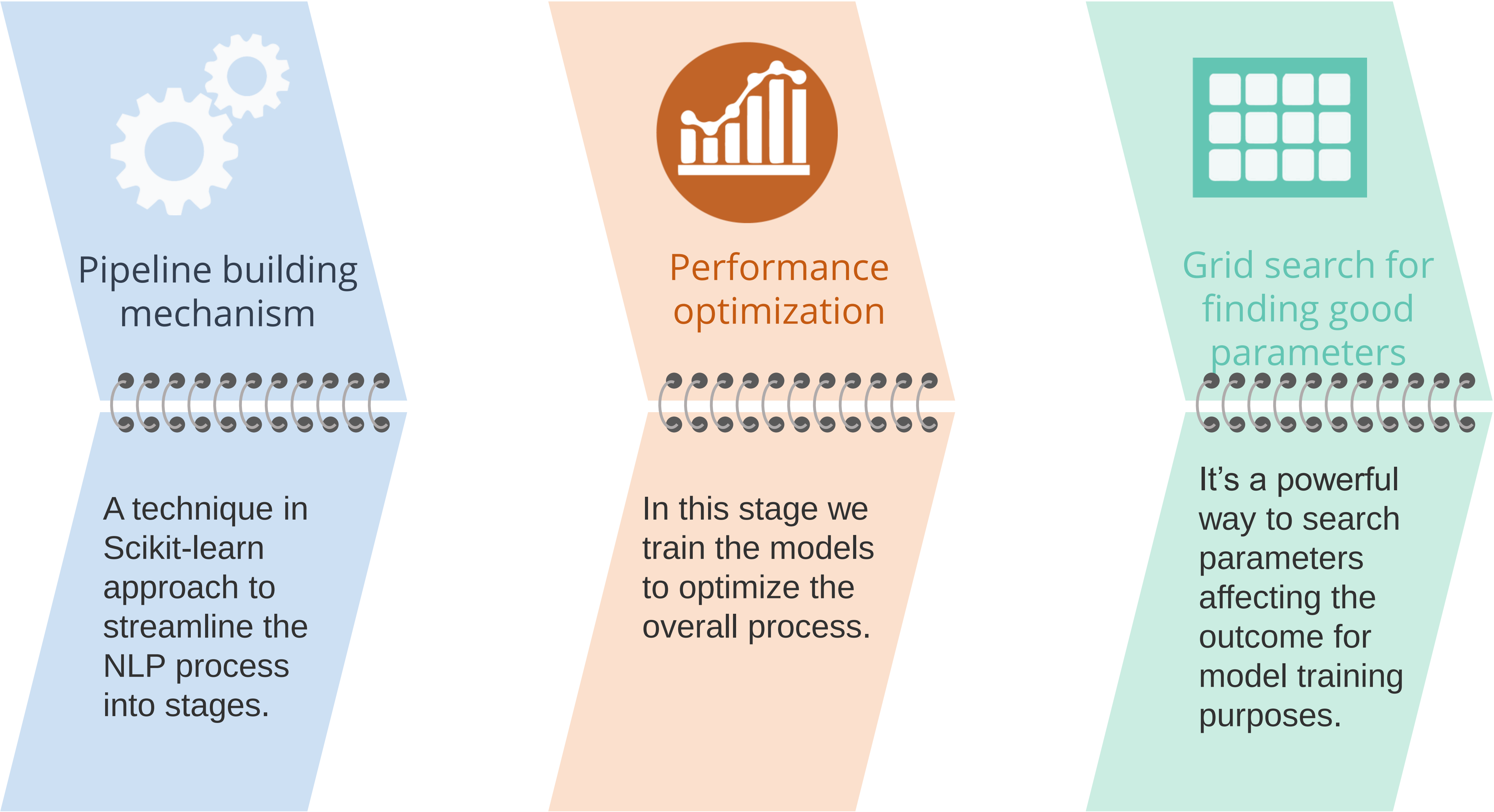
A way to extract information from data which can be text or images.

Model training

Analyze the content based on particular categories and then train them according to a specific model.

The SciKit Learn Approach (contd.)

It is a very powerful library with a set of modules to process and analyze natural language data such as texts and images and extract information using machine learning algorithms.



Pipeline building mechanism

A technique in Scikit-learn approach to streamline the NLP process into stages.

Performance optimization

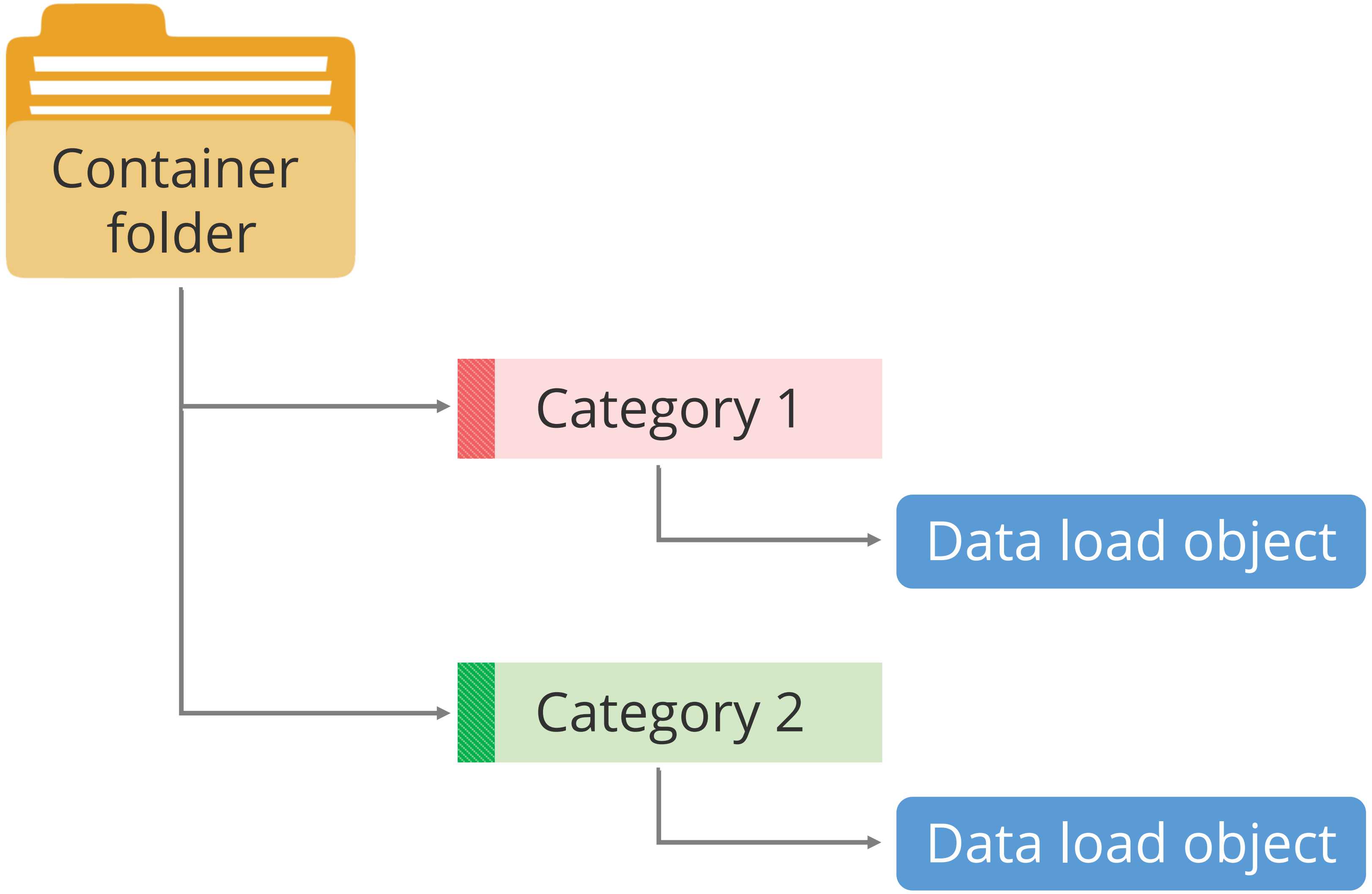
In this stage we train the models to optimize the overall process.

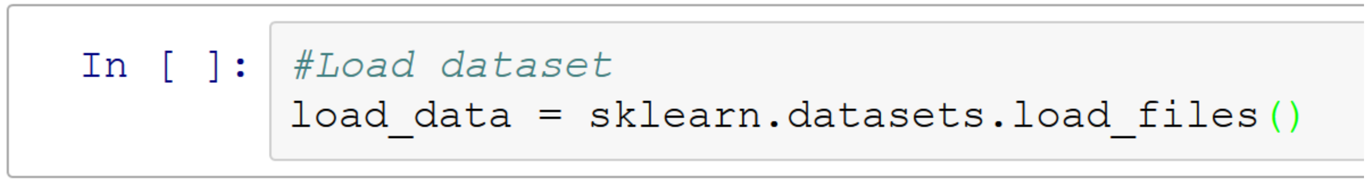
Grid search for finding good parameters

It’s a powerful way to search parameters affecting the outcome for model training purposes.

Modules to Load Content and Category

Scikit-learn has many built-in datasets. There are several methods to load these datasets with the help of a data load object.

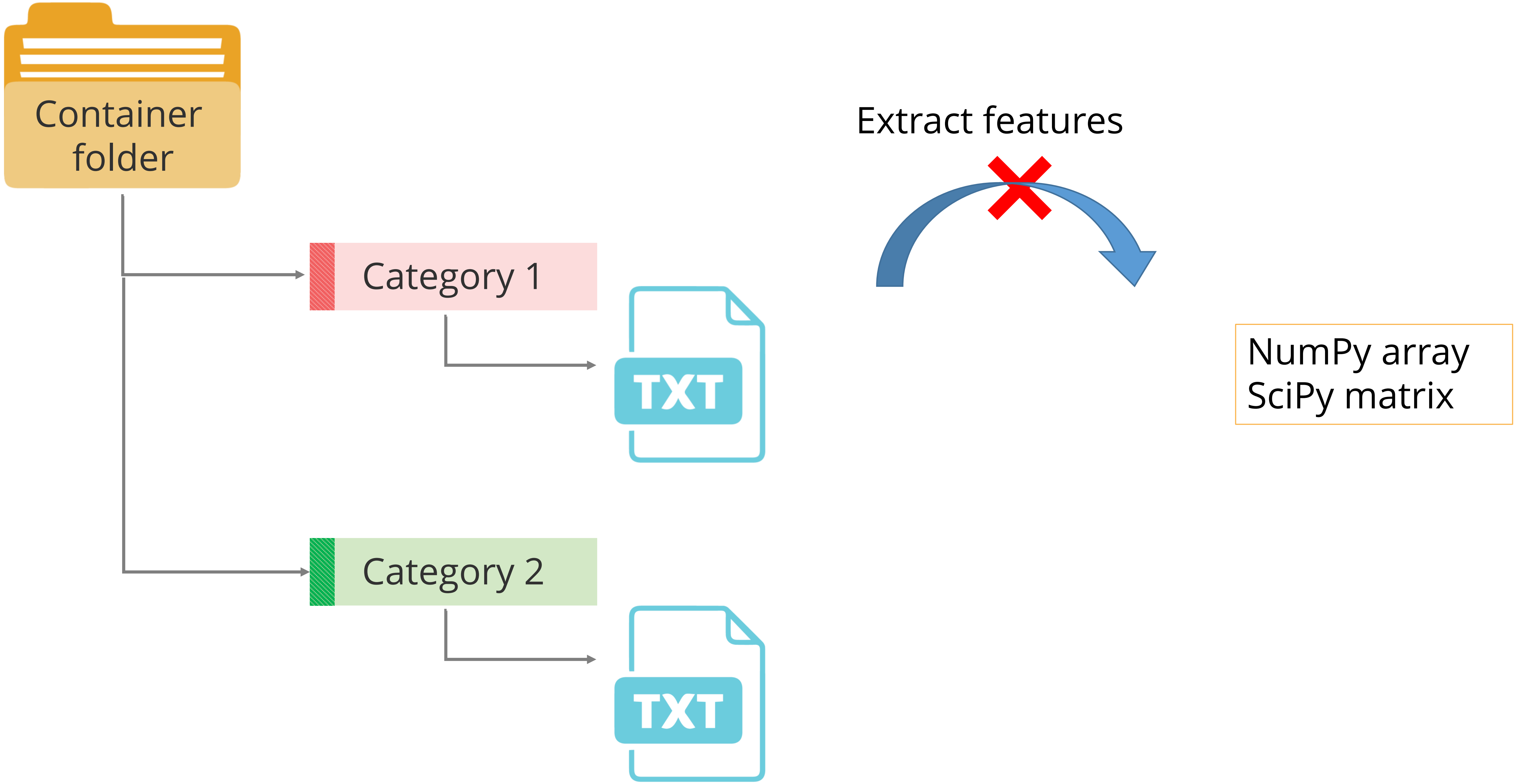




```
In [ ]: #Load dataset
        load_data = sklearn.datasets.load_files()
```

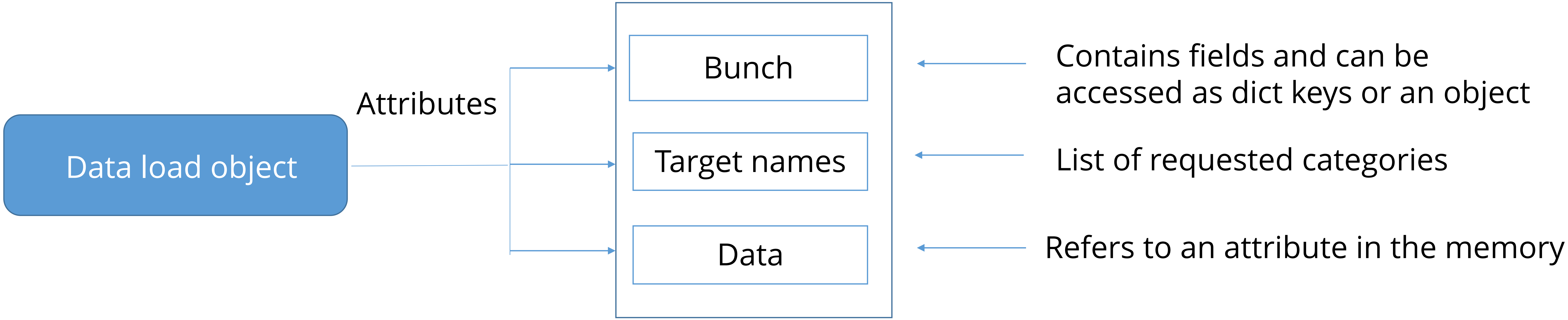
Modules to Load Content and Category (contd.)

The text files are loaded with categories as subfolder names.



Modules to Load Content and Category (contd.)

The attributes of a data load object are:



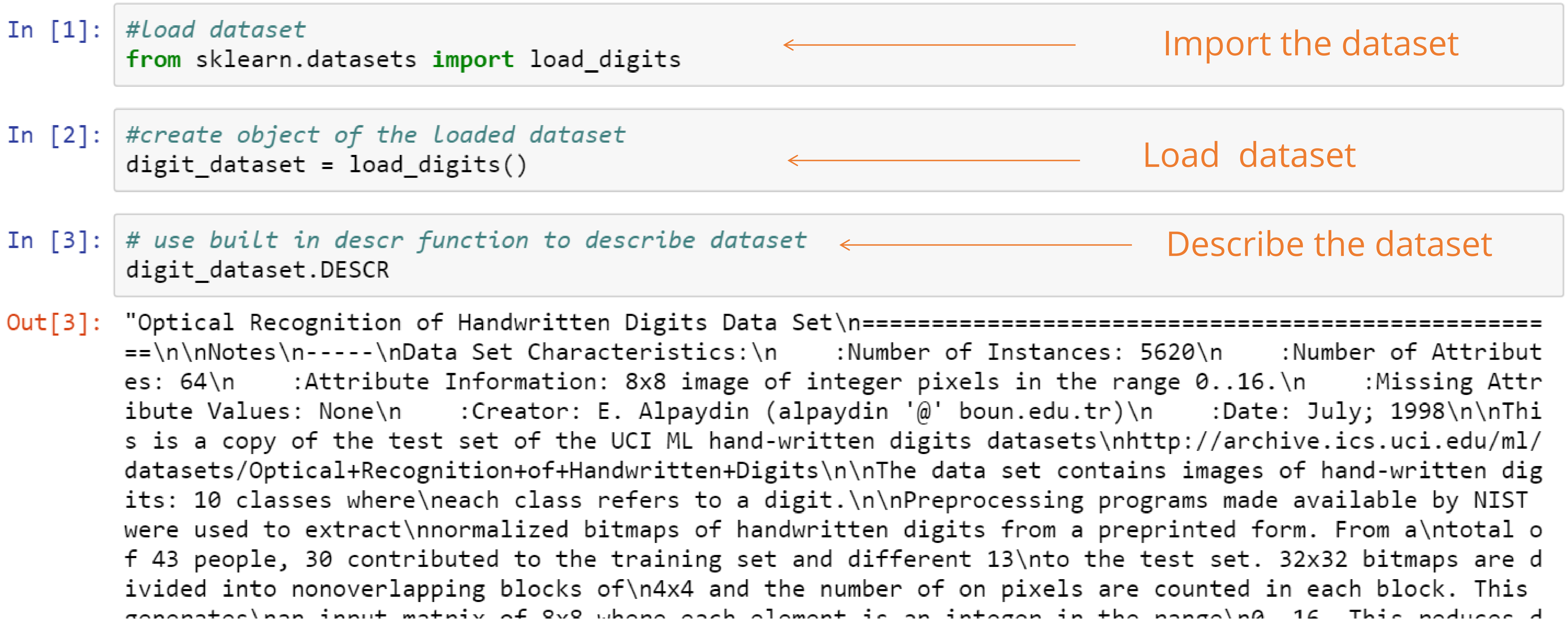
Contains fields and can be accessed as dict keys or an object

List of requested categories

Refers to an attribute in the memory

Modules to Load Content and Category (contd.)

A dataset can be loaded using scikit-learn.



```
In [1]: #load dataset
        from sklearn.datasets import load_digits
```

Import the dataset

```
In [2]: #create object of the loaded dataset
        digit_dataset = load_digits()
```

Load dataset

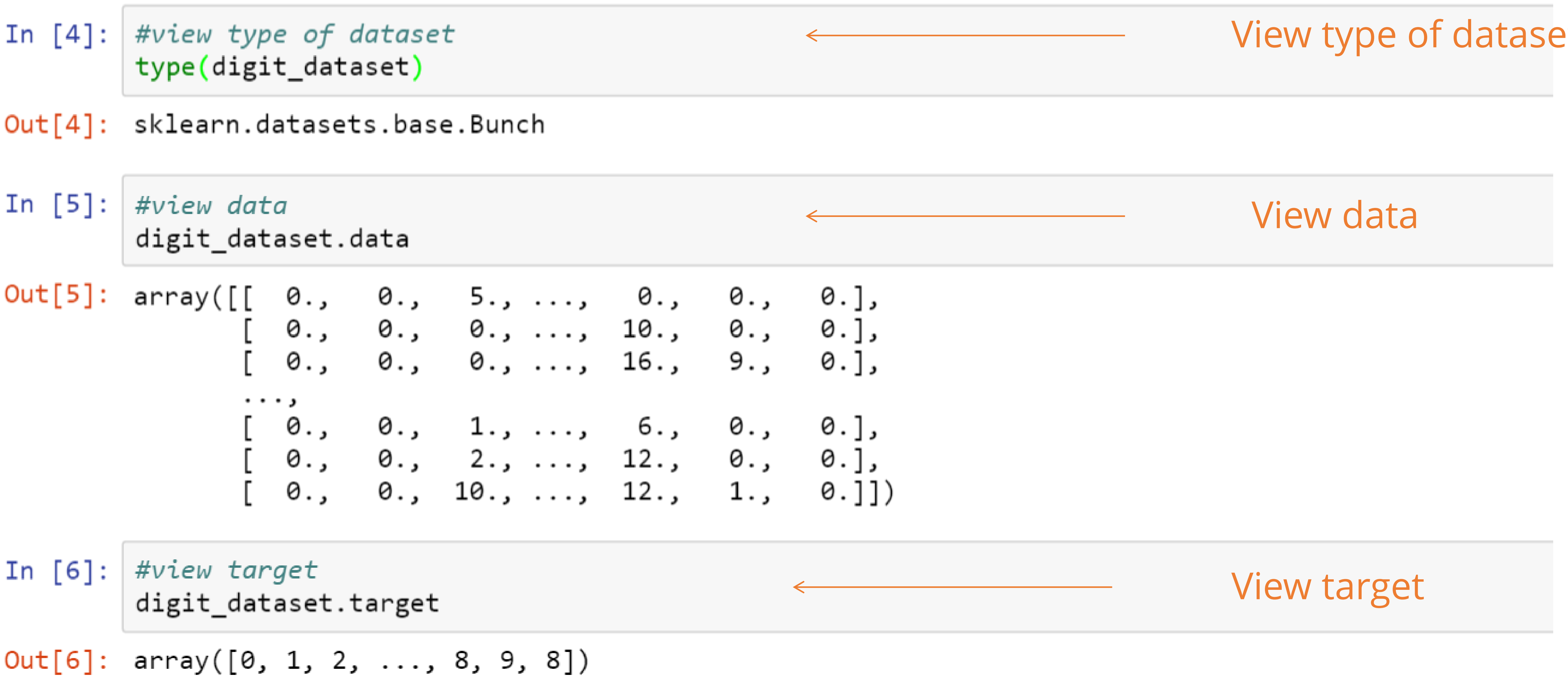
```
In [3]: # use built in descr function to describe dataset
        digit_dataset.DESCR
```

Describe the dataset

```
Out[3]: "Optical Recognition of Handwritten Digits Data Set\n====================================================
        ==\n\nNotes\n-----\nData Set Characteristics:\n    :Number of Instances: 5620\n    :Number of Attribut
        es: 64\n    :Attribute Information: 8x8 image of integer pixels in the range 0..16.\n    :Missing Attr
        ibute Values: None\n    :Creator: E. Alpaydin (alpaydin '@' boun.edu.tr)\n    :Date: July; 1998\n\nThi
        s is a copy of the test set of the UCI ML hand-written digits datasets\nhttp://archive.ics.uci.edu/ml/
        datasets/Optical+Recognition+of+Handwritten+Digits\n\nThe data set contains images of hand-written dig
        its: 10 classes where\neach class refers to a digit.\n\nPreprocessing programs made available by NIST
        were used to extract\nnormalized bitmaps of handwritten digits from a preprinted form. From a\ntotal o
        f 43 people, 30 contributed to the training set and different 13\nto the test set. 32x32 bitmaps are d
        ivided into nonoverlapping blocks of\n4x4 and the number of on pixels are counted in each block. This
        generates\nan input matrix of 8x8 where each element is an integer in the range\n0..16. This reduces d
```

Modules to Load Content and Category (contd.)

Let us see how functions like type, .data, and .target help in analyzing a dataset.



```
In [4]:  #view type of dataset
         type(digit_dataset)

Out[4]:  sklearn.datasets.base.Bunch

In [5]:  #view data
         digit_dataset.data

Out[5]:  array([[  0.,   0.,   5., ...,   0.,   0.,   0.],
                [  0.,   0.,   0., ...,  10.,   0.,   0.],
                [  0.,   0.,   0., ...,  16.,   9.,   0.],
                ...,
                [  0.,   0.,   1., ...,   6.,   0.,   0.],
                [  0.,   0.,   2., ...,  12.,   0.,   0.],
                [  0.,   0.,  10., ...,  12.,   1.,   0.]])

In [6]:  #view target
         digit_dataset.target

Out[6]:  array([0, 1, 2, ..., 8, 9, 8])
```

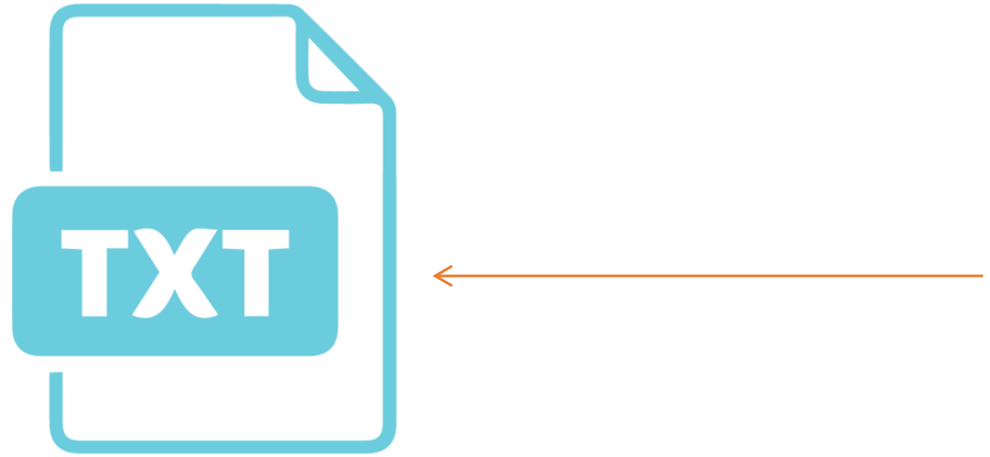
View type of dataset

View data

View target

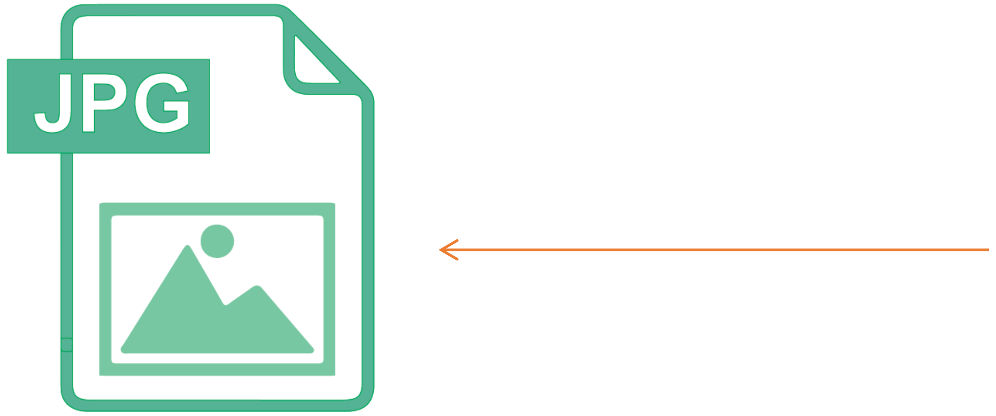
Feature Extraction

Feature extraction is a technique to convert the content into the numerical vectors to perform machine learning.



For example: Large datasets or documents

Text feature extraction

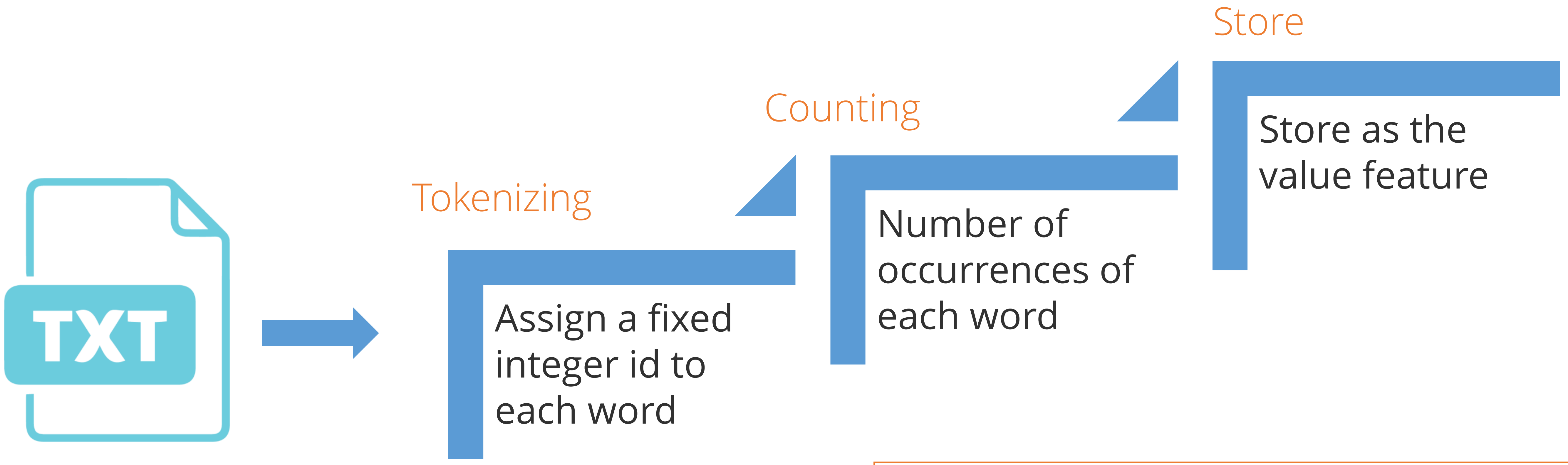


For example: Patch extraction, hierarchical clustering

Image feature extraction

Bag of Words

Bag of words is used to convert text data into numerical feature vectors with a fixed size.



Tokenizing

Assign a fixed integer id to each word

Counting

Number of occurrences of each word

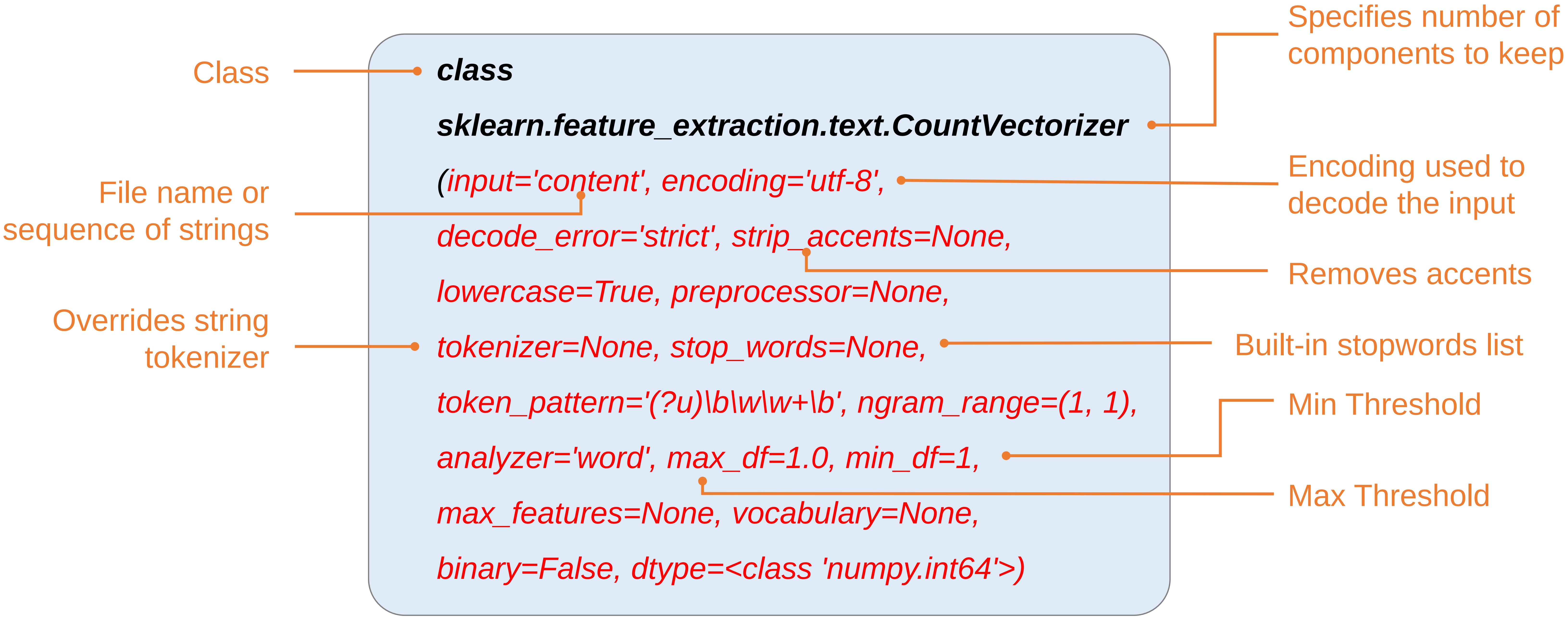
Store

Store as the value feature

Corpus of document

	Token 1	Token 2	Token 3	Token 4
Document 1	42	32	119	3
Document 2	1118	0	0	89
Document 3	0	0	0	55

CountVectorizer Class Signature



```
class
sklearn.feature_extraction.text.CountVectorizer
(input='content', encoding='utf-8',
decode_error='strict', strip_accents=None,
lowercase=True, preprocessor=None,
tokenizer=None, stop_words=None,
token_pattern='(?u)\b\w\w+\b', ngram_range=(1, 1),
analyzer='word', max_df=1.0, min_df=1,
max_features=None, vocabulary=None,
binary=False, dtype=<class 'numpy.int64'>)
```

Class

File name or sequence of strings

Overrides string tokenizer

Specifies number of components to keep

Encoding used to decode the input

Removes accents

Built-in stopwords list

Min Threshold

Max Threshold

Demo 03—Bag of Words

Demonstrate the Bag of Words technique

Text Feature Extraction Considerations

Sparse	This utility deals with sparse matrix while storing them in memory. Sparse data is commonly noticed when it comes to extracting feature values, especially for large document datasets.
Vectorizer	It implements tokenization and occurrence. Words with minimum two letters get tokenized. We can use the analyzer function to vectorize the text data.
Tf-idf	It is a term weighing utility for term frequency and inverse document frequency. Term frequency indicates the frequency of a particular term in the document. Inverse document frequency is a factor which diminishes the weight of terms that occur frequently.
Decoding	This utility can decode text files if their encoding is specified.

Model Training

An important task in model training is to identify the right model for the given dataset. The choice of model completely depends on the type of dataset.

Supervised

Models predict the outcome of new observations and datasets, and classify documents based on the features and response of a given dataset.

Example: Naïve Bayes, SVM, linear regression, K-NN neighbors

Unsupervised

Models identify patterns in the data and extract its structure. They are also used to group documents using clustering algorithms.

Example: K-means

Naïve Bayes Classifier

It is the most basic technique for classification of text.

Advantages:

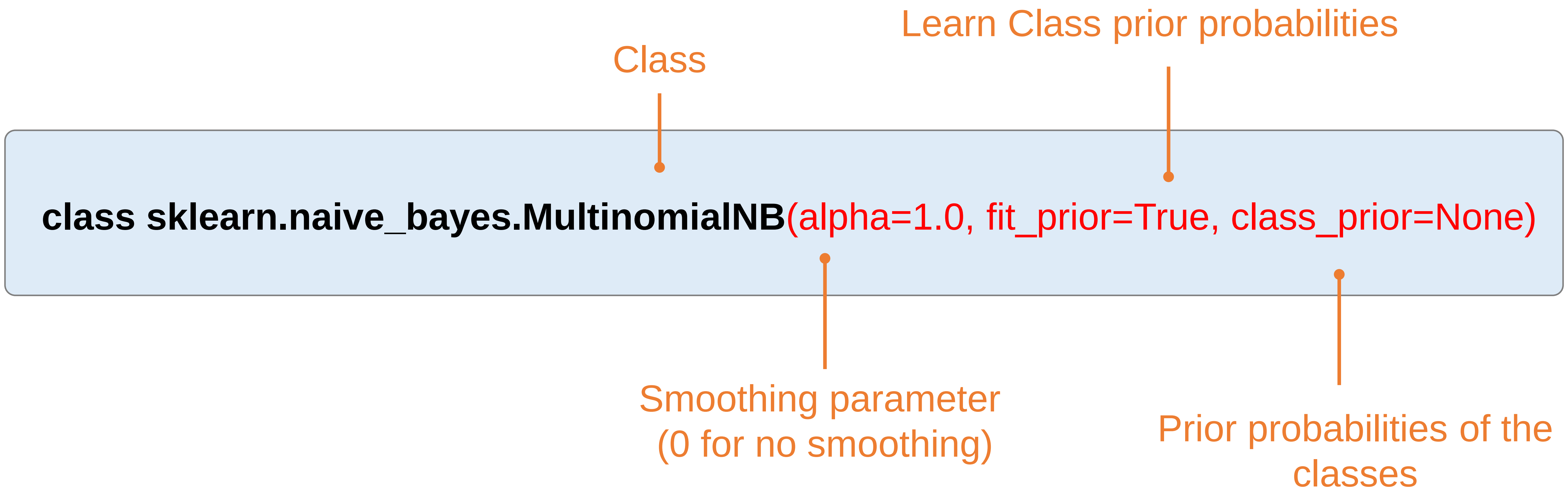
- It is efficient as it uses limited CPU and memory.
- It is fast as the model training takes less time.

Uses:

- Naïve Bayes is used for sentiment analysis, email spam detection, categorization of documents, and language detection.
- Multinomial Naïve Bayes is used when multiple occurrences of the words matter.

Naïve Bayes Classifier

Let us take a look at the signature of the multinomial Naïve Bayes classifier:



```
class sklearn.naive_bayes.MultinomialNB(alpha=1.0, fit_prior=True, class_prior=None)
```

Class

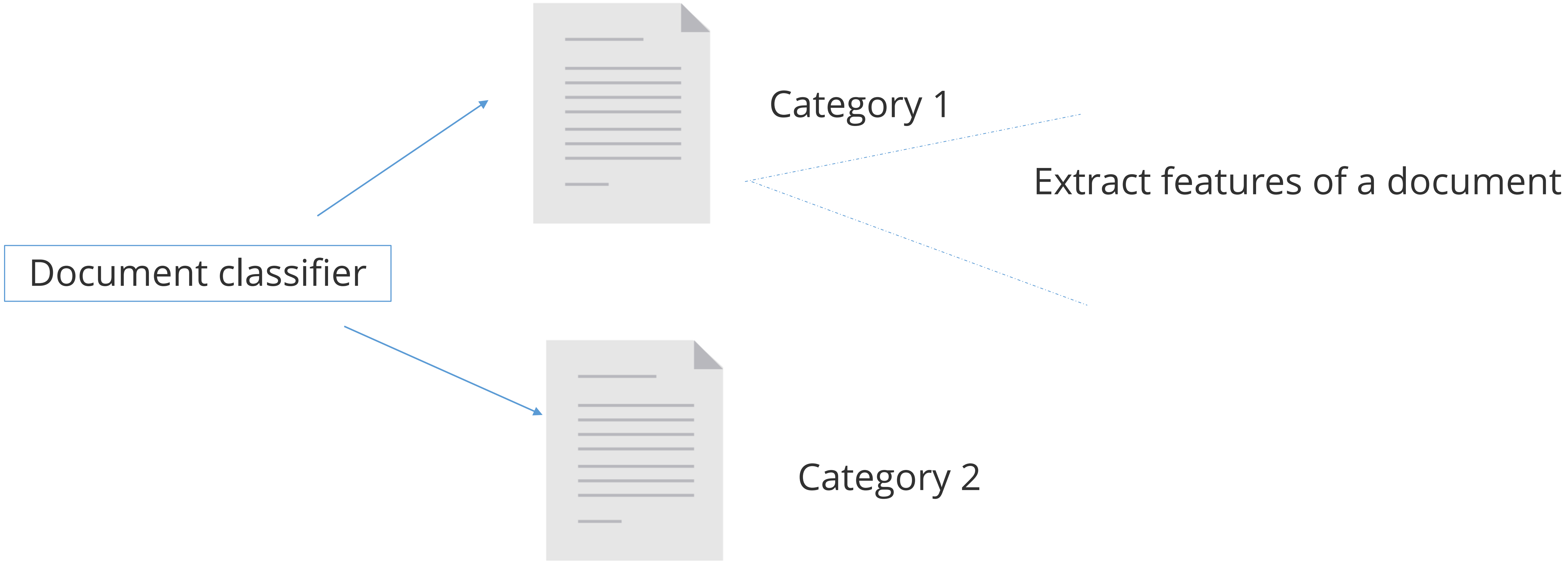
Learn Class prior probabilities

Smoothing parameter
(0 for no smoothing)

Prior probabilities of the classes

Grid Search and Multiple Parameters

Document classifiers can have many parameters and a Grid approach helps to search the best parameters for model training and predicting the outcome accurately.



Document classifier

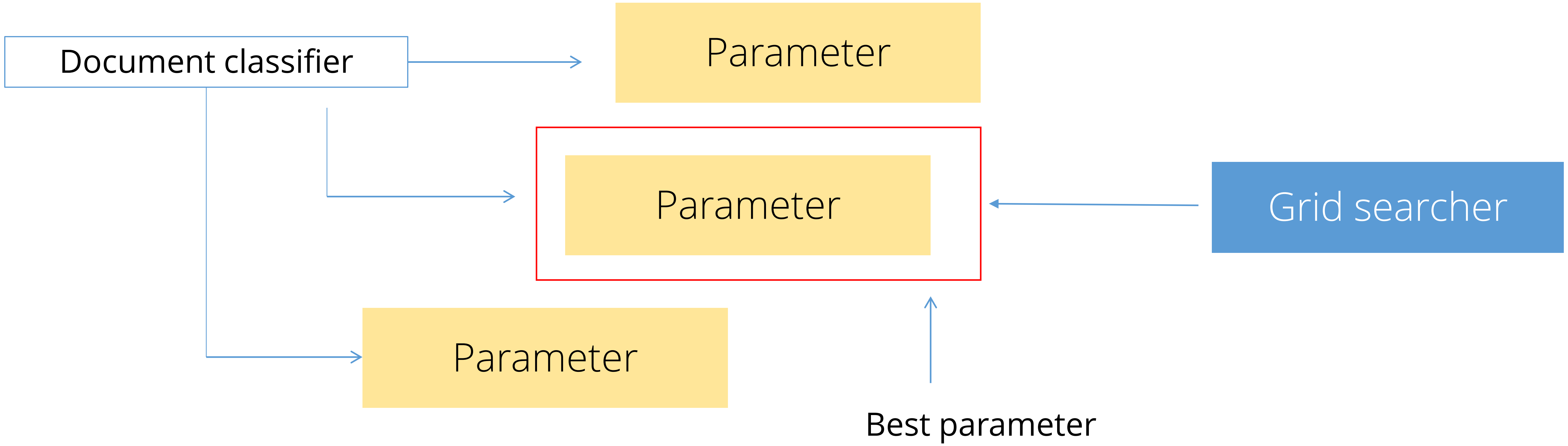
Category 1

Extract features of a document

Category 2

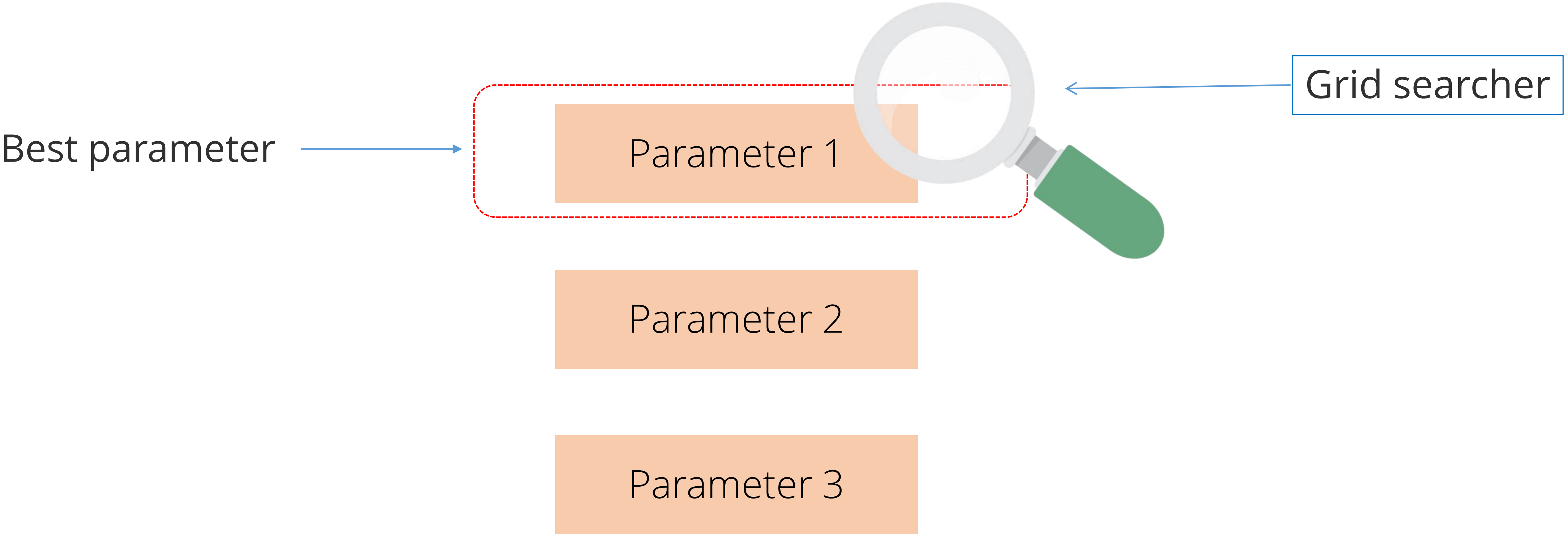
Grid Search and Multiple Parameters (contd.)

Document classifiers can have many parameters and a Grid approach helps to search the best parameters for model training and predicting the outcome accurately.



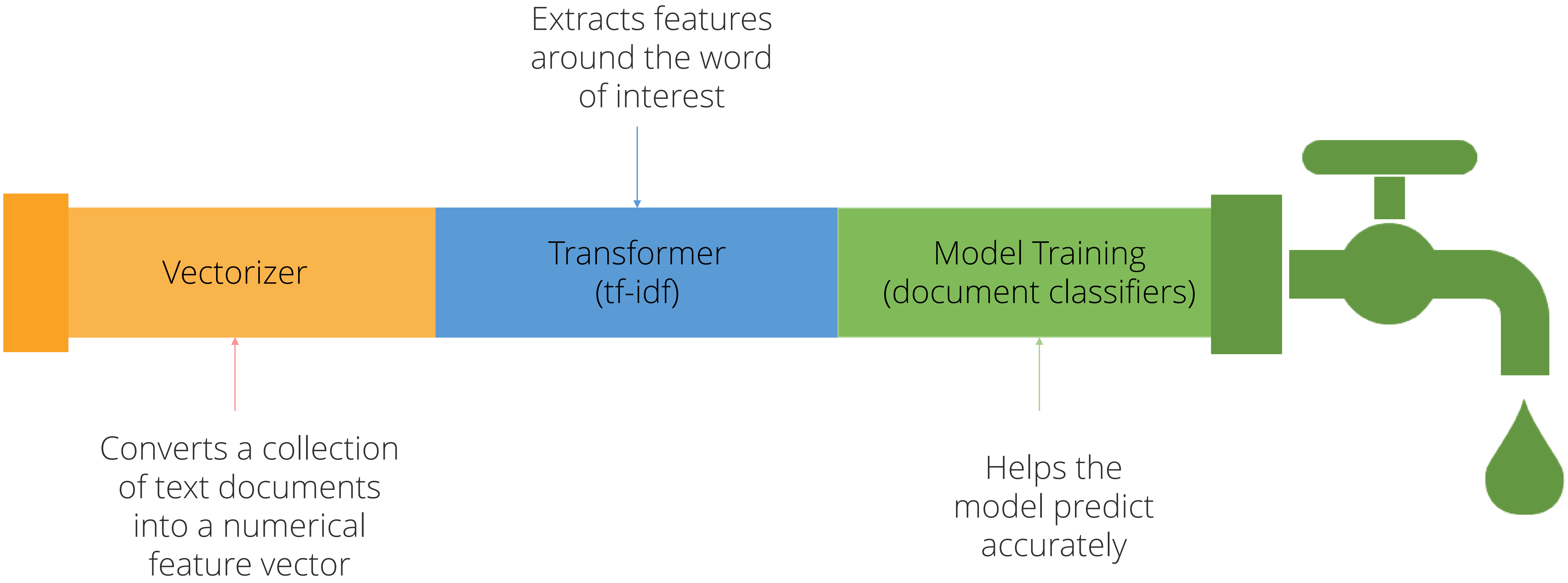
Grid Search and Multiple Parameters (contd.)

In grid search mechanism, the whole dataset can be divided into multiple grids and a search can be run on entire grids or a combination of grids.



Pipeline

A pipeline is a combination of vectorizers, transformers, and model training.



Extracts features around the word of interest

Vectorizer

Transformer (tf-idf)

Model Training (document classifiers)

Converts a collection of text documents into a numerical feature vector

Helps the model predict accurately

Demo 04—Pipeline and Grid Search

Demonstrate the Pipeline and grid search technique

Assignment

Assignment 01

Problem

Instructions

Analyze the given Spam Collection dataset to:

1.View information on the spam data,

2.View the length of messages,

3. Define a function to eliminate stopwords,

4. Apply Bag of Words,

5. Apply tf-idf transformer, and

6. Detect Spam with Naïve Bayes model.

Assignment 01

Problem

Instructions

Instructions on performing the assignment:

- Download the Spam Collection dataset from the “Resource” tab. Upload it using the right syntax to use and analyze it.

Common instructions:

- If you are new to Python, download the “Anaconda Installation Instructions” document from the “Resources” tab to view the steps for installing Anaconda and the Jupyter notebook.
- Download the “Assignment 01” notebook and upload it on the Jupyter notebook to access it.
- Follow the provided cues to complete the assignment.

Assignment

Assignment 02

Problem Assignment

Analyze the Sentiment dataset using NLP to:

1. View the observations,
2. Verify the length of the messages and add it as a new column,
3. Apply a transformer and fit the data in the bag of words,
4. Print the shape for the transformer, and
5. Check the model for predicted and expected values.

Assignment 02

Problem

Instructions

Instructions on performing the assignment:

- Download the Sentiment dataset from the “Resource” tab. Upload it to your Jupyter notebook to work on it.

Common instructions:

- If you are new to Python, download the “Anaconda Installation Instructions” document from the “Resources” tab to view the steps for installing Anaconda and the Jupyter notebook.
- Download the “Assignment 02” notebook and upload it on the Jupyter notebook to access it.
- Follow the provided cues to complete the assignment.

Quiz

QUIZ

1

What is the tf-idf value in a document?

a. Directly proportional to the number of times a word appears

b. Inversely proportional to the number of times a word appears

c. Offset by frequency of the words in corpus

d. Increase with frequency of the words in corpus

QUIZ

1

What is the tf-idf value in a document?

a. Directly proportional to the number of times a word appears

b. Inversely proportional to the number of times a word appears

c. Offset by frequency of the words in corpus

d. Increase with frequency of the words in corpus

The correct answer is. a, c

Explanation: td-idf value reflects how important a word is to a document. It is directly proportional to the number of times a word appears and is offset by frequency of the words in corpus.

QUIZ 2

In grid search if n_jobs = -1, then which of the following is correct?

a. Uses only 1 CPU core

b. Detects all installed cores and uses them all

c. Searches for only one parameter

d. All parameters will be searched on a given grid

QUIZ
2

In grid search if n_jobs = -1, then which of the following is correct?

a. Uses only 1 CPU core

b. Detects all installed cores and uses them all

c. Searches for only one parameter

d. All parameters will be searched on a given grid

The correct answer is. b

Explanation: Detects all installed cores on the machine and uses all of them.

QUIZ 3

Identify the correct example of Topic Modeling from the following options:

a. Machine translation

b. Speech recognition

c. News aggregators

d. Sentiment analysis

QUIZ
3

Identify the correct example of Topic Modeling from the following options:

a. Machine translation

b. Speech recognition

c. News aggregators

d. Sentiment analysis

The correct answer is. c

Explanation: 'Topic model' is statistical modeling and used to find latent groupings in the documents based upon the words. For example, news aggregators.

QUIZ
4

How do we save memory while operating on Bag of Words which typically contain high-dimensional sparse datasets?

a. Distribute datasets in several blocks or chunks

b. Store only non zero parts of the feature vectors

c. Flatten the dataset

d. Decode them

QUIZ
4

How do we save memory while operating on Bag of Words which typically contain high-dimensional sparse datasets?

a. Distribute datasets in several blocks or chunks

b. Store only non zero parts of the feature vectors

c. Flatten the dataset

d. Decode them

The correct answer is. b

Explanation: In features vector, there will be several values with zeros. The best way to save memory is to store only non zero parts of the feature vectors.

QUIZ
5

What is the function of the sub-module feature_extraction.text.CountVectorizer?

a. Convert a collection of text documents to a matrix of token counts

b. Convert a collection of text documents to a matrix of token occurrences

c. Transform a count matrix to a normalized form

d. Convert a collection of raw documents to a matrix of TF-IDF features

QUIZ 5

What is the function of the sub-module feature_extraction.text.CountVectorizer?

a. Convert a collection of text documents to a matrix of token counts

b. Convert a collection of text documents to a matrix of token occurrences

c. Transform a count matrix to a normalized form

d. Convert a collection of raw documents to a matrix of TF-IDF features

The correct answer is. a

Explanation: The function of the sub-module feature_extraction.text.CountVectorizer is to convert a collection of text documents to a matrix of token counts.

Key Takeaways

Let us take a quick recap of what we have learned in the lesson:

- Natural Language Processing is an automated way to understand, analyze human languages, and extract information from such data by applying machine learning algorithms.
- There are various approaches of Natural Language Processing to analyze text data which are inter-dependent or can be independently applied in a document.
- There are two feature extraction techniques, which are text feature extraction and image feature extraction.
- Pipeline building can be used to streamline the NLP process into stages.
- Grid search mechanism is used to perform exhaustive search on the best parameters that impacts the model.

This concludes ‘Natural Language Processing (NLP) with Scikit-Learn’

The next lesson is ‘Data Visualization in Python with Matplotlib and Bokeh’