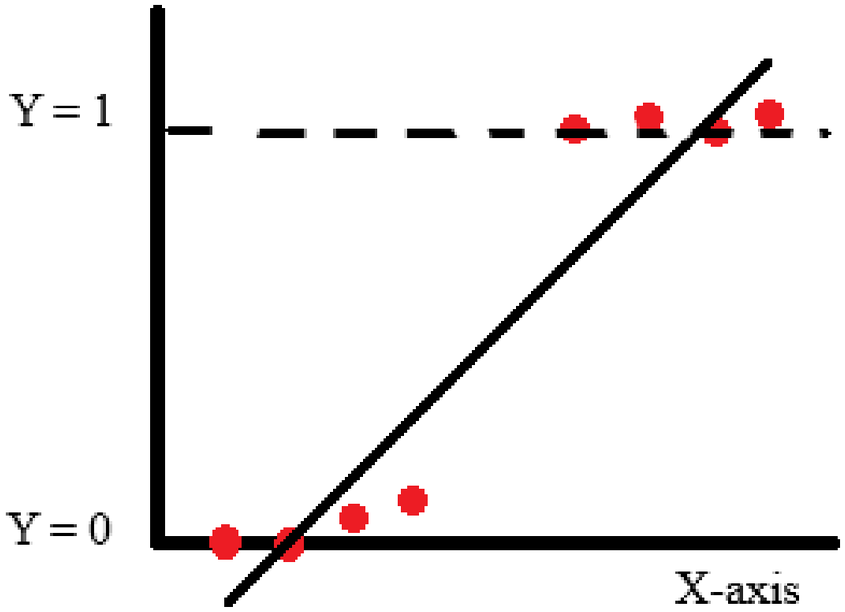
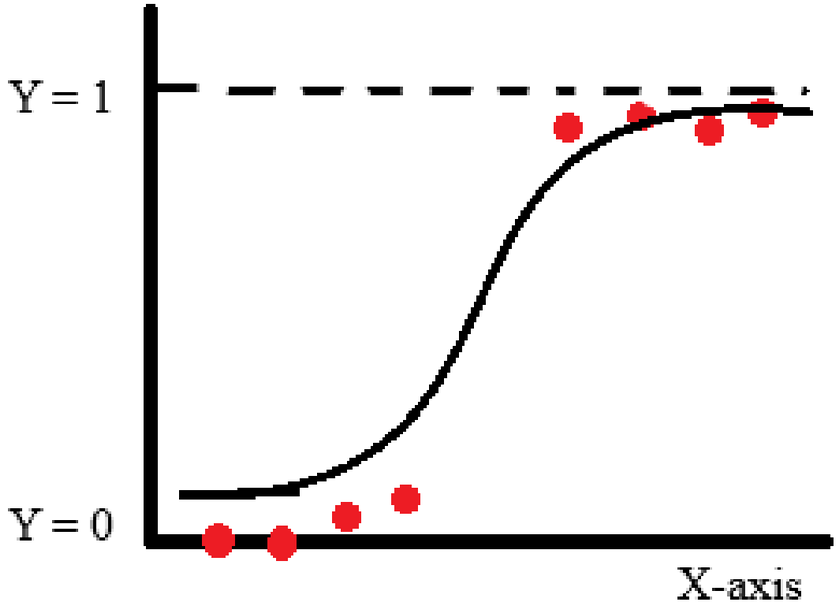
Classification problems

- Product and movie reviews: positive or negative sentiment (binary classification)
- Tweets about airline companies: positive, neutral and negative (multi-class classification)

Linear and logistic regressions



Linear regression

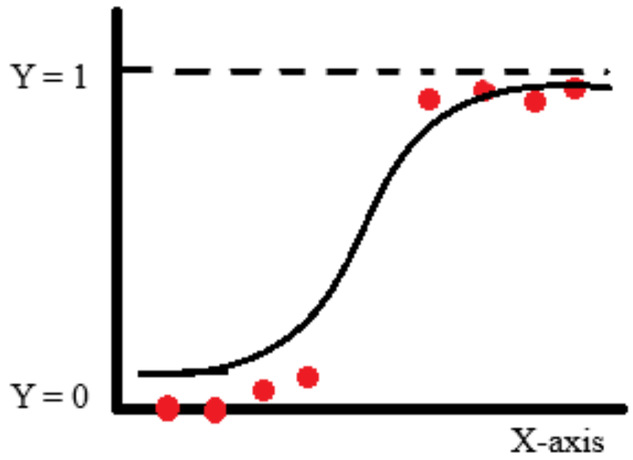


Logistic regression

Logistic function

- Linear regression: numeric outcome
- Logistic regression: probability:

$$Probability(sentiment = positive|review)$$



Logistic regression

Logistic regression in Python

```
from sklearn.linear_model import LogisticRegression
```

```
log_reg = LogisticRegression().fit(X, y)
```

Measuring model performance

> Accuracy: Fraction of predictions our model got right.

- The higher and closer the accuracy is to 1, the better

```
# Accuracy using score
score = log_reg.score(X, y)
print(score)
```

```
0.9009
```

Using accuracy score

```
# Accuracy using accuracy_score
from sklearn.metrics import accuracy_score
```

```
y_predicted = log_reg.predict(X)
acurracy = accuracy_score(y, y_predicted)
```

```
0.9009
```

Did we really predict the sentiment well?

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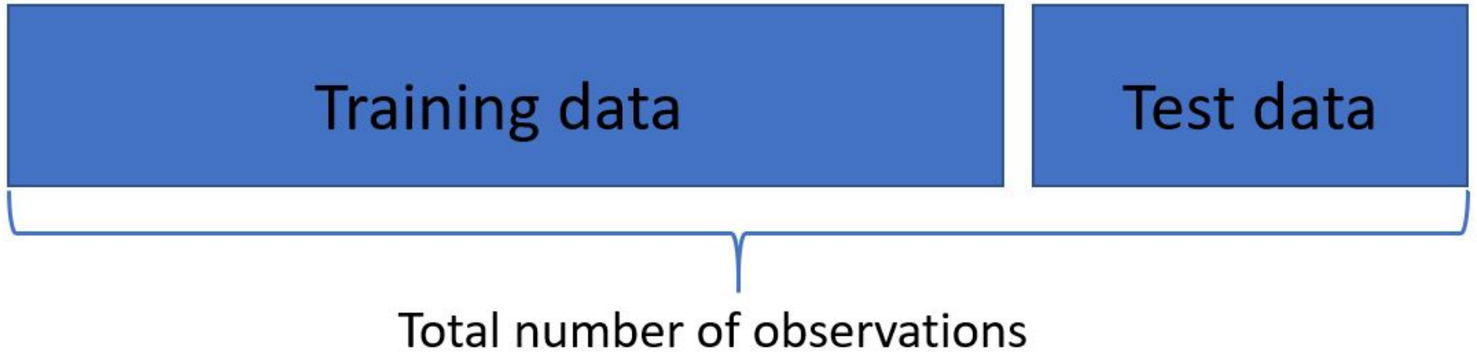
Train/test split



- Training set: used to train the model (70-80% of the whole data)
- Testing set: used to evaluate the performance of the model

Train/test in Python

```
from sklearn.model_selection import train_test_split
```

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=123, stratify=y
```

- **X** : features
- **y** : labels
- **test_size**: proportion of data used in testing
- **random_state**: seed generator used to make the split
- **stratify**: proportion of classes in the sample produced will be the same as the proportion of values provided to this parameter

Logistic regression with train/test split

```
log_reg = LogisticRegression().fit(X_train, y_train)
```

```
print('Accuracy on training data: ', log_reg.score(X_train, y_train))
```

```
0.76
```

```
print('Accuracy on testing data: ', log_reg.score(X_test, y_test))
```

```
0.73
```

Accuracy score with train/test split

```
from sklearn.metrics import accuracy_score
```

```
log_reg = LogisticRegression().fit(X_train, y_train)
```

```
y_predicted = log_reg.predict(X_test)
print('Accuracy score on test data: ', accuracy_score(y_test, y_predicted))
```

```
0.73
```

Confusion matrix

	Actual = 1	**Actual = 0**
Predicted = 1	True positive	False positive
Predicted = 0	False negative	True negative

Confusion matrix in Python

```
from sklearn.metrics import confusion_matrix
```

```
log_reg = LogisticRegression().fit(X_train, y_train)
y_predicted = log_reg.predict(X_test)
```

```
print(confusion_matrix(y_test, y_predicted)/len(y_test))
```

```
[[0.3788 0.1224]
 [0.1352 0.3636]]
```

Logistic regression: revisted

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Complex models and regularization

Complex models:

- Complex model that captures the noise in the data (overfitting)
- Having a large number of features or parameters

Regularization:

- A way to simplify and ensure we have a less complex model

Regularization in a logistic regression

```
from sklearn.linear_model import LogisticRegression
```

```
# Regularization arguments
LogisticRegression(penalty='l2', C=1.0)
```

- L2: shrinks all coefficients towards zero
- High values of C: low penalization, model fits the training data well.
- Low values of C: high penalization, model less flexible.

Predicting a probability vs. predicting a class

```
log_reg = LogisticRegression.fit(X_train, y_train)
```

```
# Predict labels
y_predicted = log_reg.predict(X_test)
```

```
# Predict probability
y_probab = log_reg.predict_proba(X_test)
```

Predicting a probability vs. predicting a class

```
y_probab
array([[0.5002245, 0.4997755],
       [0.4900345, 0.5099655],
        ...,
       [0.7040499, 0.2959501]])
```

```
# Select the probabilities of class 1
y_probab = log_reg.predict_proba(X_test)[:, 1]
```

```
array([0.4997755, 0.5099655 ..., 0.2959501]])
```

Model metrics with predicted probabilities

- Raise **ValueError** when applied with probabilities.
- Accuracy score and confusion matrix work with classes.

```
# Default probability encoding:
# If probability >= 0.5, then class 1 Else class 0
```

Bringing it all together

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The Sentiment Analysis problem

> Sentiment analysis as the process of understanding the opinion of an author about a subject

- Movie reviews
- Amazon product reviews
- Twitter airline sentiment
- Various emotionally charged literary examples

Exploration of the reviews

- Basic information about size of reviews
- Word clouds
- Features for the length of reviews: number of words, number of sentences
- Feature detecting the language of a review

Numeric transformations of sentiment-carrying columns

- Bag-of-words
- TfIdf vectorization

```
from sklearn.feature_extraction.text import CountVectorizer, TfidfVectorizer
```

```
# Vectorizer syntax
vect = CountVectorizer().fit(data.text_column)
X = vect.transform(data.text_column)
```

Arguments of the vectorizers

- stop words: non-informative, frequently occurring words
- n-gram range: use phrases not only single words
- control size of vocabulary: max_features, max_df, min_df
- capturing a pattern of tokens: remove digits or certain characters

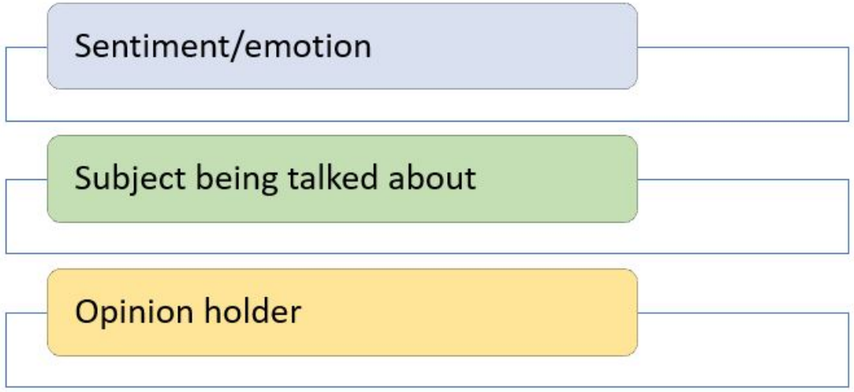
Important but NOT arguments to the vectorizers

- lemmas and stems

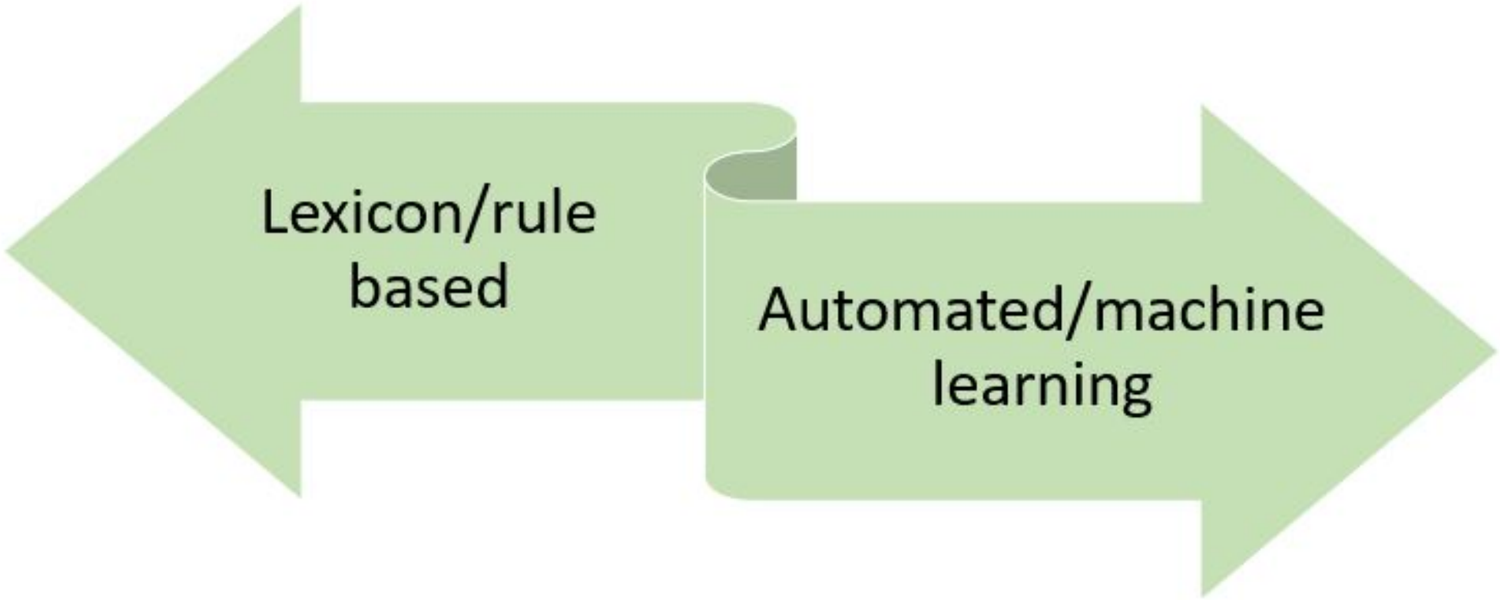
Supervised learning model

- Logistic regression classifier to predict the sentiment
- Evaluated with accuracy and confusion matrix
- Importance of train/test split

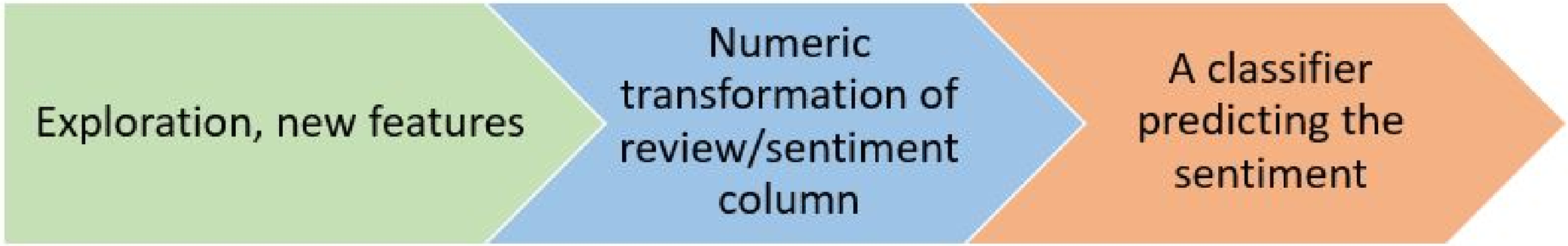
The Sentiment Analysis world



Sentiment analysis types



The automated sentiment analysis system



Congratulations!

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