Machine Learning

Indah Agustien Siradjuddin

Logistic Regression ¶

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Regression Vs. Classification

Regression : input - real value, output - real value
Classification : input - real value, output - kelas

Binary Classifier

- map the input into output, which has only two kinds of value, i.e. positive or negative, 1 or 0
- Target data : only two values, i.e. 1 or 0

E.g. :

- Email : Spam or ham
- Cancer : benign or malignant
- CC transaction : Fraud or regular transaction

Output :

$y \in 0, 1$, where:

- 0 is negative class
- 1 is positive class

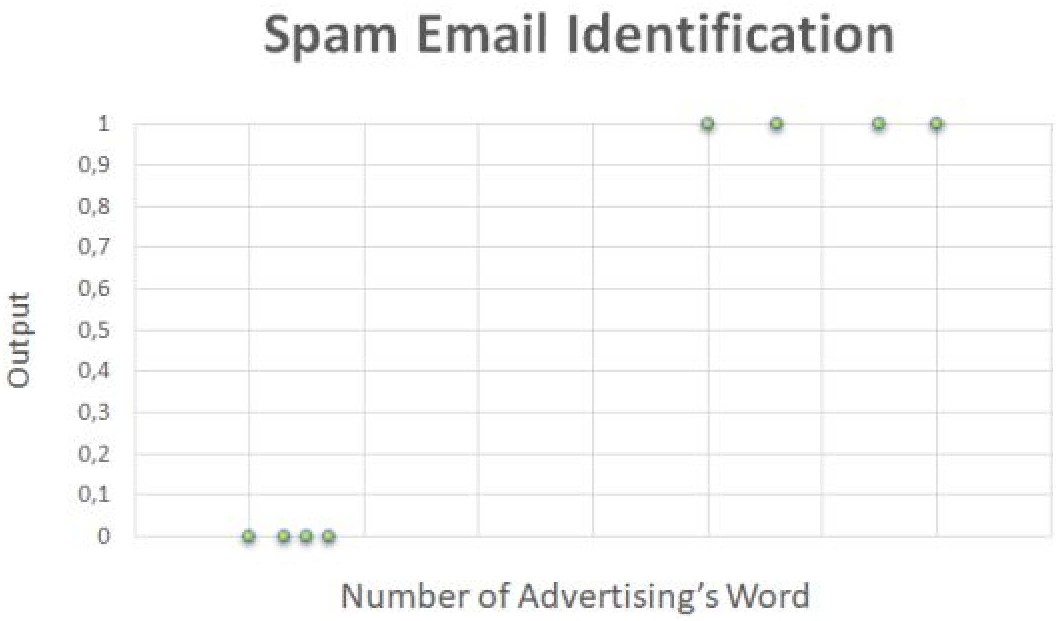
note: depends on how you determine which one is the positive or negative class

Linear Regression for Classification

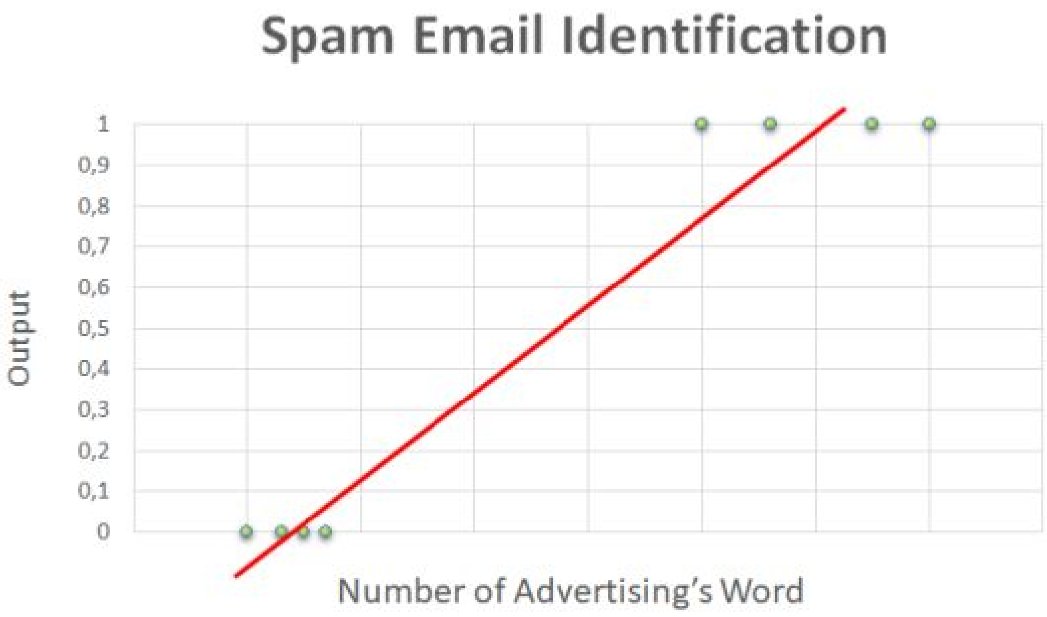
Spam Email Identification

based on number of advertising's words.
Output value :

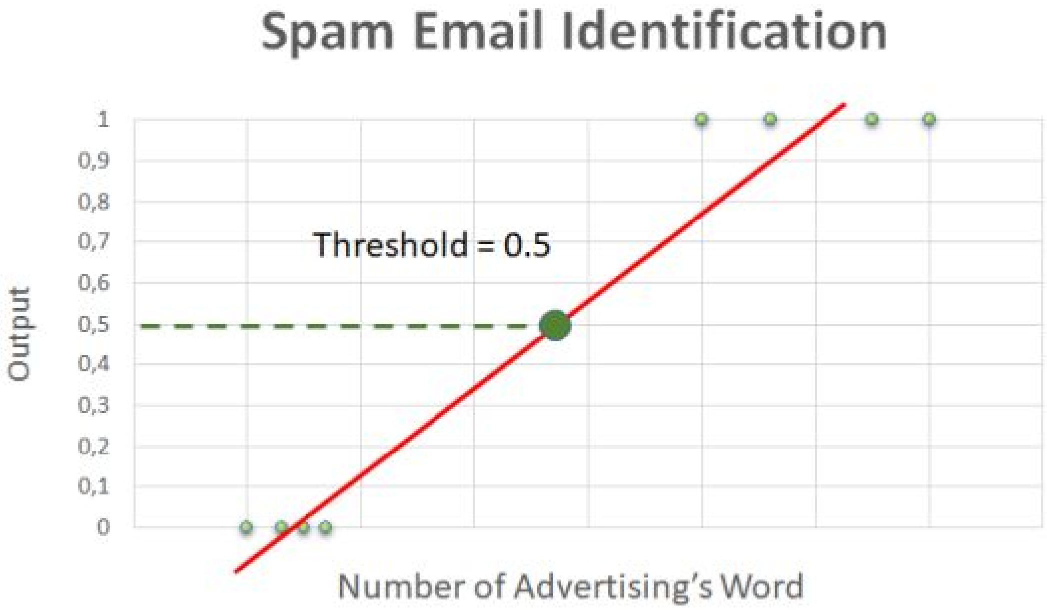
- Spam : 1
- Ham : 0



based on the training dataset, below is the trained model

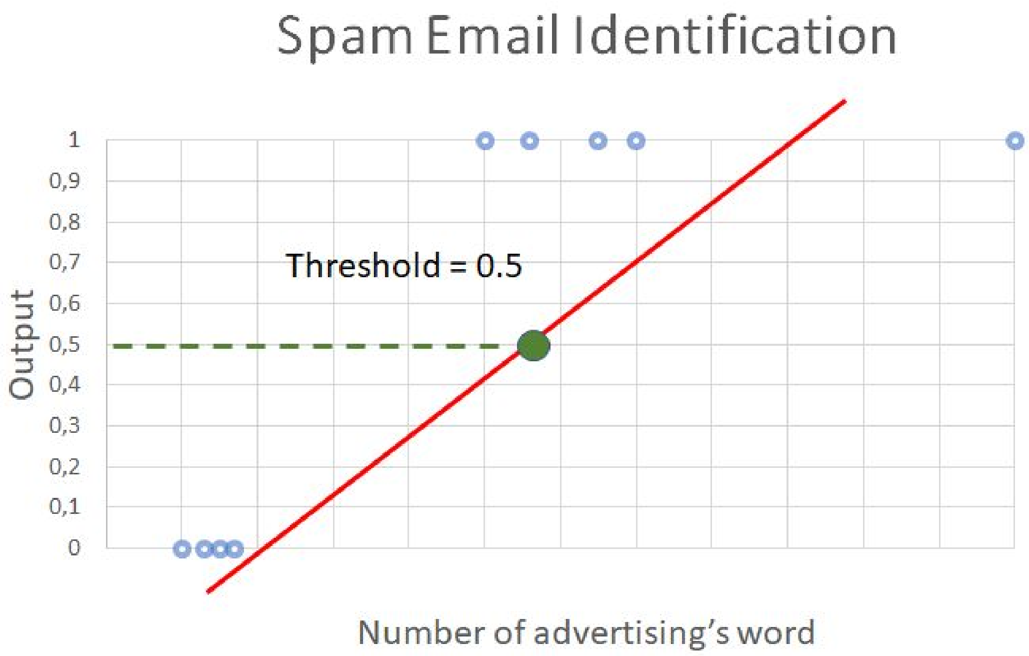


Linear Regression for classification --> using threshold Threshold is used to classify the data: $output < threshold$ then $output = 0$, else $output = 1$



based on the threshold, which data are belongs to spam or ham ?

However, if new data is included, then the model should be updated



based on the threshold, which data are belongs to spam or ham ?

Therefore, Linear Regression Model can't be used for the classification

Logistic Regression

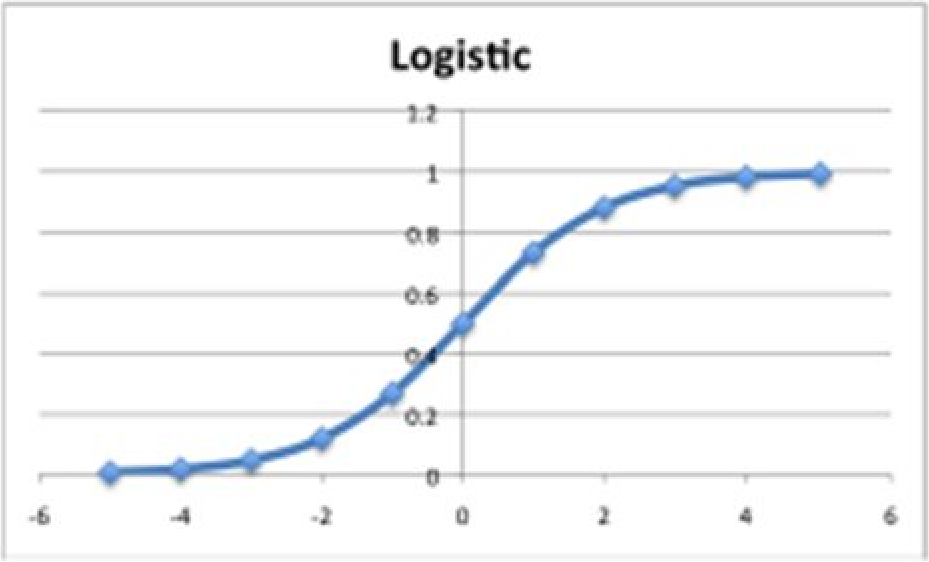
Definition

- predict the probability of a data belongs to certain class
- binary classifier
- Supervised classifier

Logistic Function

output of logistic function falls to $0 \leq y \leq 1$ Fungsi logistik :

$$y = f(x) = \frac{1}{1 + e^{-x}}$$



Linear Regression :

$$f(x; w) = w_0 + w_1x_1 + w_2x_2 + \ldots + w_dx_d$$

Logistic Regression :

$$f(x; w) = \frac{1}{1 + e^{-(w_0 + w_1x_1 + w_2x_2 + \ldots + w_dx_d)}}$$

Update weight with Gradient descent :

$$w_j = w_j + \eta(y^i - f(x^i))f(x^i)(1 - f(x^i))x_j^i$$

In [3]:

```
x=np.array([[3,3],[1,2],[3,4],[1,2],[3,3],[8,3],[5,2],[7,2],[9,0],[8,4]])
target=np.array([[0],[0],[0],[0],[0],[1],[1],[1],[1],[1]])
test=np.array([[1,2]])
```

Logistic Regression with Scikit

Training/Learning

- load dataset (features and target)
- create Model
- Training/Learning

Testing

- Load Model
- test model with new Data / Generalize

In [2]:

```
from sklearn.linear_model.logistic import LogisticRegression
import numpy as np
```

from three lines code, define :

- data training (input) ? x
- target ? target
- number of data training ? 10
- number of attribute ? 2
- data test ? test

In [4]:

```
classifier = LogisticRegression()
classifier.fit(x,target)
print(classifier.intercept_,classifier.coef_)
pred=classifier.predict(test)
print('prediction = ',pred)
```

```
[-0.40885175] [[ 0.83023895 -1.10760329]]
prediction =  [0]

C:\Users\Indah Agustin\Anaconda3\lib\site-packages\sklearn\linear_model\lo
gistic.py:432: FutureWarning: Default solver will be changed to 'lbfgs' in
0.22. Specify a solver to silence this warning.
  FutureWarning)
C:\Users\Indah Agustin\Anaconda3\lib\site-packages\sklearn\utils\validatio
n.py:724: DataConversionWarning: A column-vector y was passed when a 1d ar
ray was expected. Please change the shape of y to (n_samples, ), for examp
le using ravel().
  y = column_or_1d(y, warn=True)
```

Logistic Regression with your own code

In [5]:

```
import simpleLinear
```

In [6]:

```
simpleLinear.logRegression(10,0.3,x,target)
```

```
w= [[0.]
 [0.]
 [0.]]
output= [0.5]  error - 0 = [-0.5]
w= [[-0.0375]
 [-0.1125]
 [-0.1125]]
output= [0.4073334]  error - 1 = [-0.4073334]
w= [[-0.06700066]
 [-0.14200066]
 [-0.17150132]]
output= [0.23523062]  error - 2 = [-0.23523062]
w= [[-0.07969586]
 [-0.18008625]
 [-0.22228211]]
output= [0.3308493]  error - 3 = [-0.3308493]
w= [[-0.10166968]
 [-0.20206008]
 [-0.26622976]]
output= [0.18145225]  error - 4 = [-0.18145225]
w= [[-0.10975487]
 [-0.22631563]
 [-0.29048531]]
output= [0.05777239]  error - 5 = [0.94222761]
w= [[-0.09436789]
 [-0.10321983]
 [-0.24432439]]
output= [0.2499056]  error - 6 = [0.7500944]
w= [[-0.05218571]
 [ 0.1076911 ]
 [-0.15996002]]
output= [0.59429076]  error - 7 = [0.40570924]
w= [[-0.02283963]
 [ 0.31311363]
 [-0.10126787]]
output= [0.94241497]  error - 8 = [0.05758503]
w= [[-0.02190211]
 [ 0.32155135]
 [-0.10126787]]
output= [0.89524163]  error - 9 = [0.10475837]
w= [[-0.01895471]
 [ 0.34513054]
 [-0.08947827]]
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 [ 0.18064813]
 [-0.2852426 ]]
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 [ 0.11401584]
 [-0.37408566]]
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 [ 0.09306605]
 [-0.41598523]]
output= [0.24851372]  error - 4 = [-0.24851372]
w= [[-0.15172067]
```

```
 [ 0.05129607]
 [-0.45775522]]
output= [0.24701099]  error - 5 = [0.75298901]
w= [[-0.10970466]
 [ 0.38742415]
 [-0.33170719]]
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w= [[-0.09676127]
 [ 0.45214111]
 [-0.3058204 ]]
output= [0.92104172]  error - 7 = [0.07895828]
w= [[-0.09503862]
 [ 0.46419963]
 [-0.30237511]]
output= [0.98341868]  error - 8 = [0.01658132]
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 [ 0.46492966]
 [-0.30237511]]
output= [0.91796245]  error - 9 = [0.08203755]
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 [ 0.47975695]
 [-0.29496147]]
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 [-0.4727127 ]]
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 [-0.53065782]]
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 [-0.5641532 ]]
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```

```
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 [-0.93719675]]
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w= [[-0.36114018]
```

```
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output= [0.95620879]  error - 7 = [0.04379121]
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 [ 0.78418951]
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 [ 0.82139086]
 [-0.99611619]]
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 [ 0.76139894]
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w= [[-0.3843761 ]
 [ 0.8460705 ]
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output= [0.99927619]  error - 8 = [0.00072381]
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 [ 0.84607191]
 [-1.12688941]]
output= [0.86722491]  error - 9 = [0.13277509]
```

Accuracy

The simplest performance measure for classification is calculate the true prediction of all data test :

$$akurasi = \frac{True}{NumberOfData}$$

In [7]:

```python
from sklearn.metrics import accuracy_score
import numpy as np
```

In [8]:

```python
target=np.array([0,0,0,0,0,1,1,1,1,1])
pred=np.array([0,1,0,0,0,0,0,1,1,1])
acc=accuracy_score(target,pred)
print(acc)
```

```
0.7
```

Confusion Matrix

Calculate True Positive, True Negative, False Positive, and False Negative

Positive - Negative : class
True - False : is predicted result equal to the target class
Email identification : spam identification
Positive class : Spam Email Negative class : ham email

True Positive : if data is predicted into positive class, and the target is positive class, i.e. spam email (output = spam, target =spam

True Negative : if data is predicted into negative class, and the target is negative class, i.e. ham email (output = ham, target = ham)

False Positive : if data is predicted into positive class, and the target is negative class, (output = spam, target = ham)

False Negative : if data is predicted into negative class, and the target is positive class, (output = ham, target = spam)

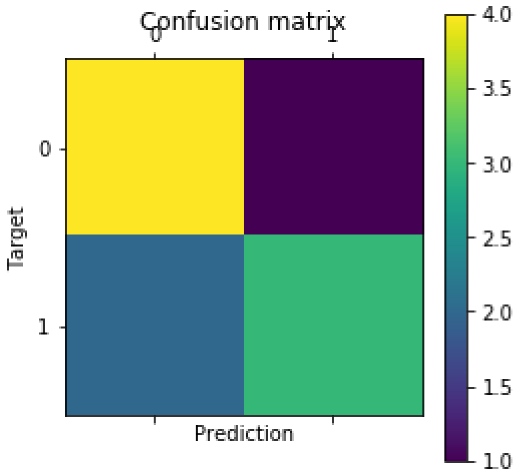
In [9]:

```
from sklearn.metrics import confusion_matrix
import matplotlib.pyplot as plt
```

In [10]:

```
target=np.array([0,0,0,0,0,1,1,1,1,1])
pred=np.array([0,1,0,0,0,0,0,1,1,1])
confusionMatrix = confusion_matrix(target, pred)
print(confusionMatrix)
plt.matshow(confusionMatrix)
plt.title('Confusion matrix')
plt.colorbar()
plt.ylabel('Target')
plt.xlabel('Prediction')
plt.show()
```

```
[[4 1]
 [2 3]]
```



Precision - Recall

$precision = \frac{TP}{TP+FP}$

$recall = \frac{TP}{TP+FN}$

In [11]:

```
from sklearn.metrics import precision_score
from sklearn.metrics import recall_score
print(precision_score(target, pred))
print(recall_score(target, pred))
```

```
0.75
0.6
```