LOGISTIC REGRESSION

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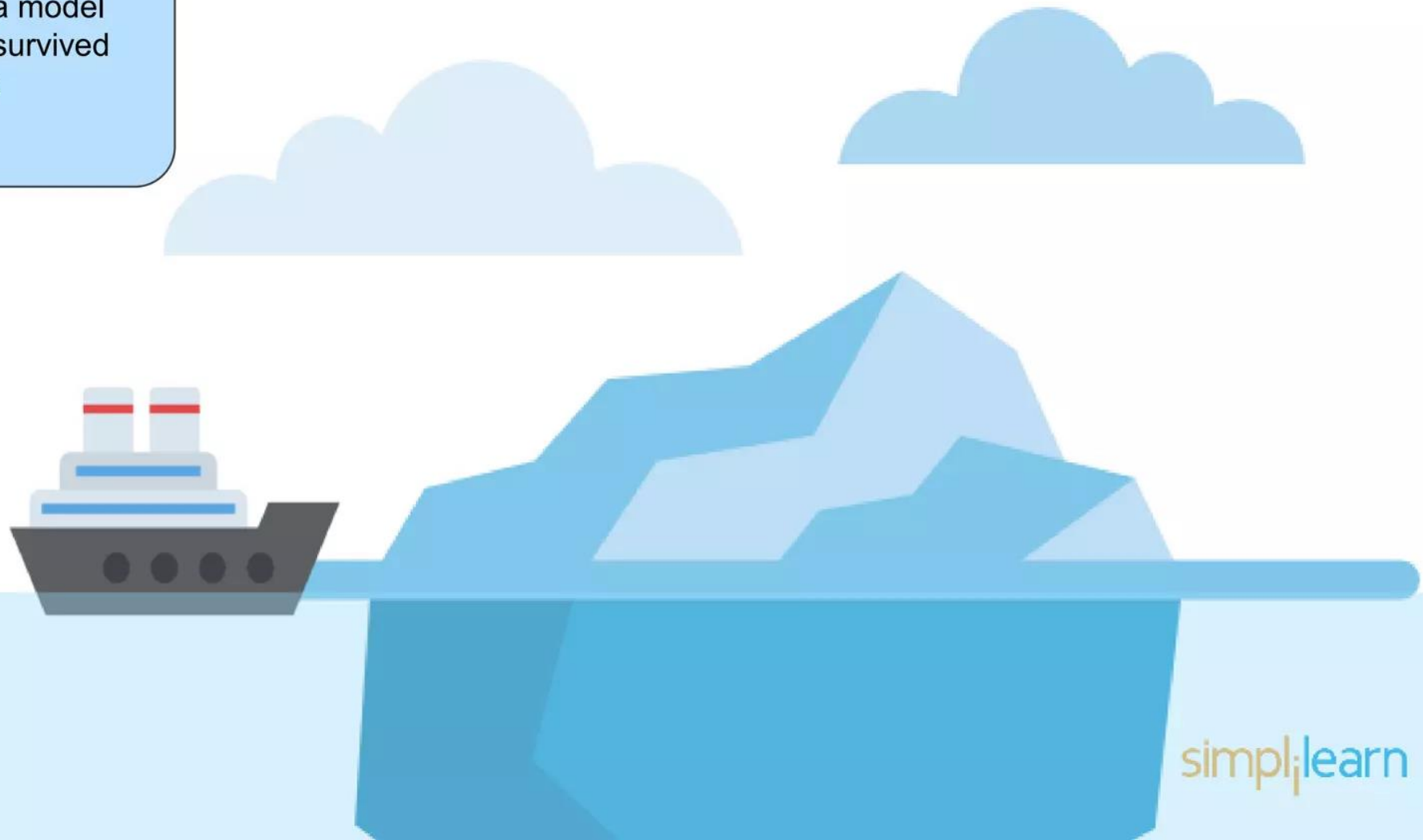
Surviving the Titanic

Suppose, you have to build a model to predict how many people survived the Titanic shipwreck



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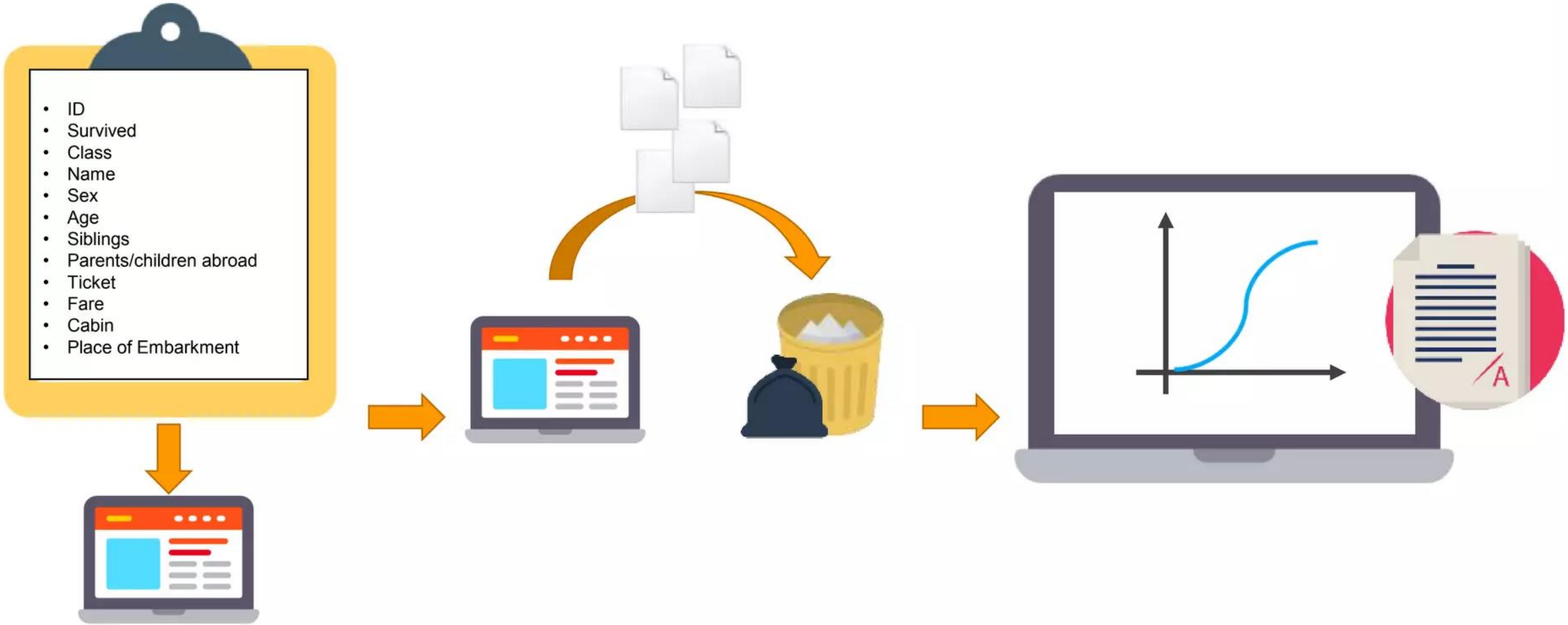
Surviving the Titanic



Teaching the model with the passenger dataset

Dropping the non-essential components of the dataset

Determining the survival of passengers and evaluating the model

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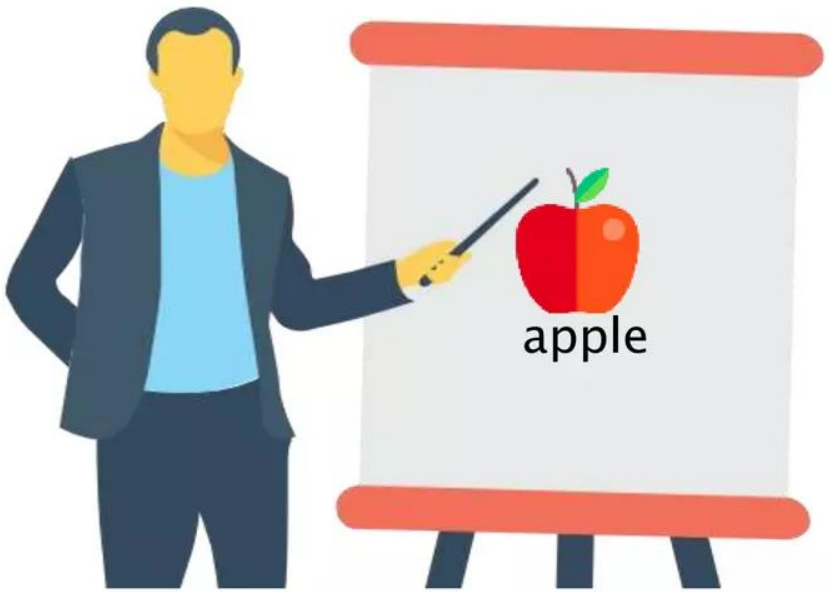
Agenda

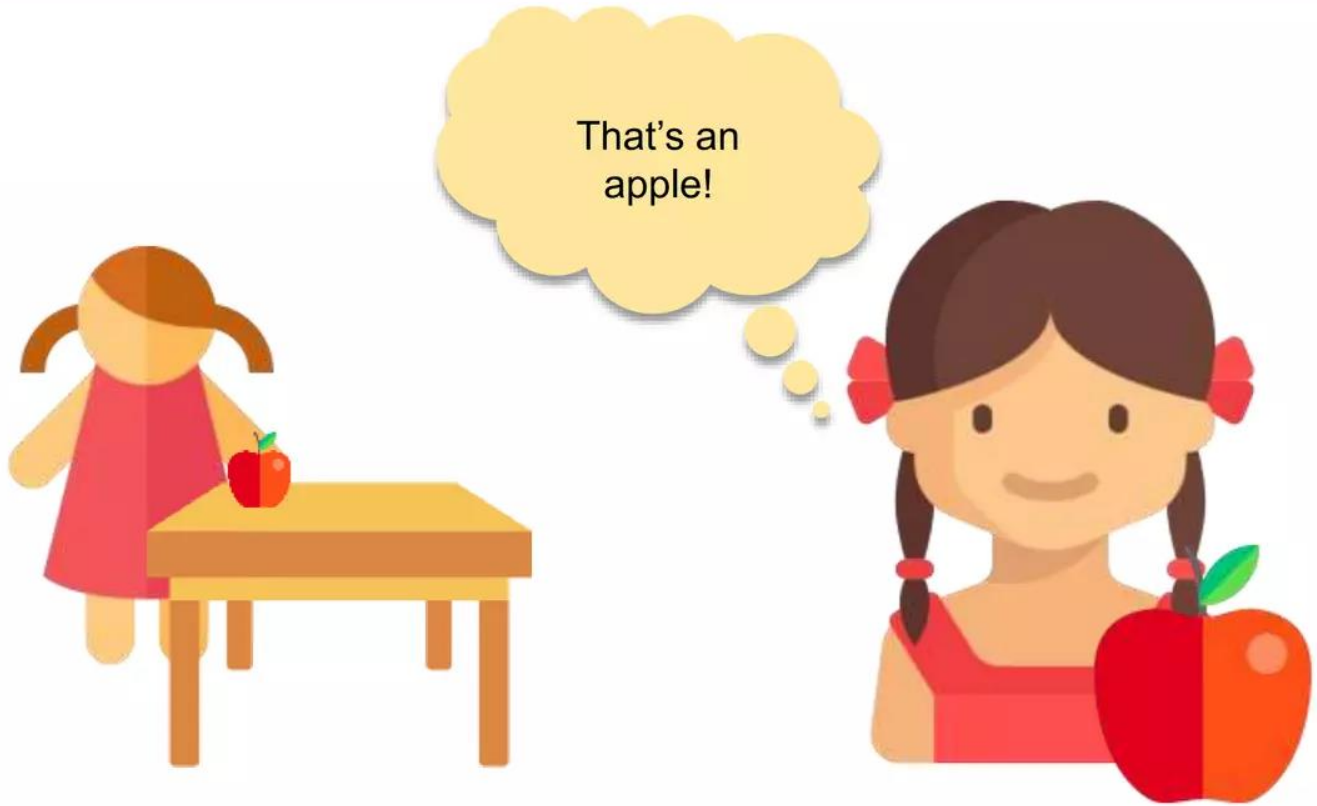
- What is Supervised Learning?
- What is Classification? What are some of its solutions?
- What is Logistic Regression?
- Comparing Linear and Logistic Regression
- Logistic Regression applications
- Use Case – Predicting the number in an image

What is Supervised Learning?

What is Supervised Learning?



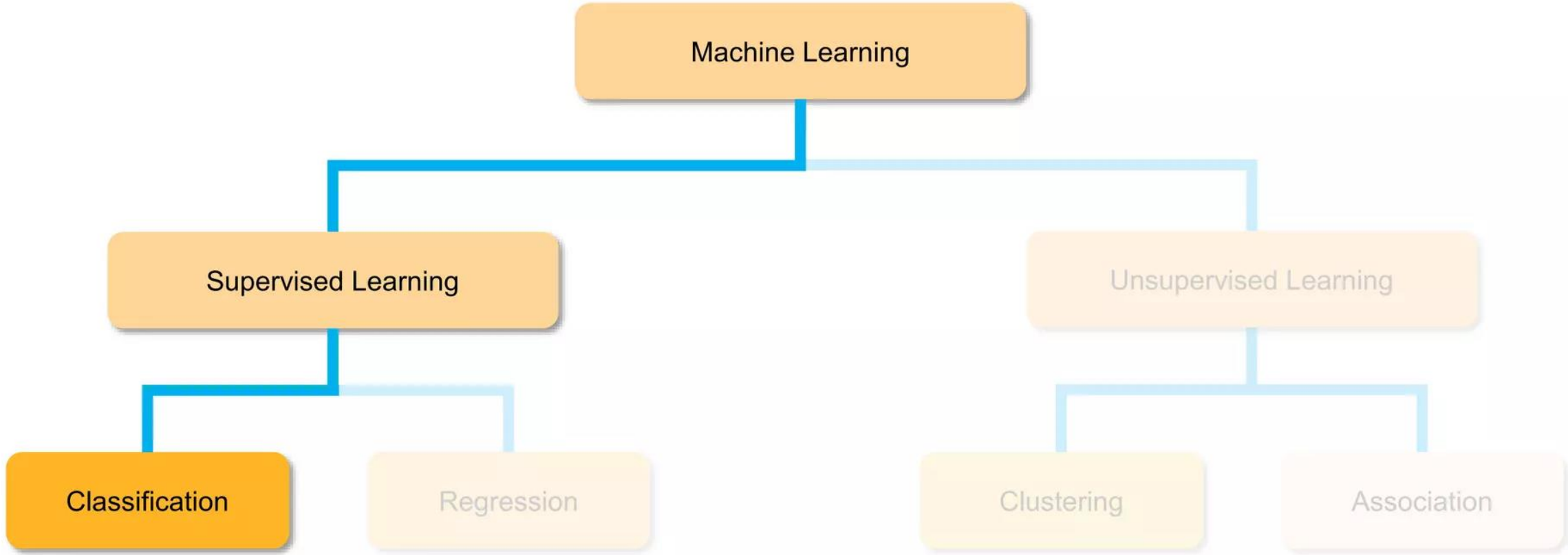
Teacher teaches child



Child recognizes an apple when she sees it again

A model is able to make predictions based on past data

Where does Logistic Regression fit it?



The systems predicts future outcomes based on training from past input

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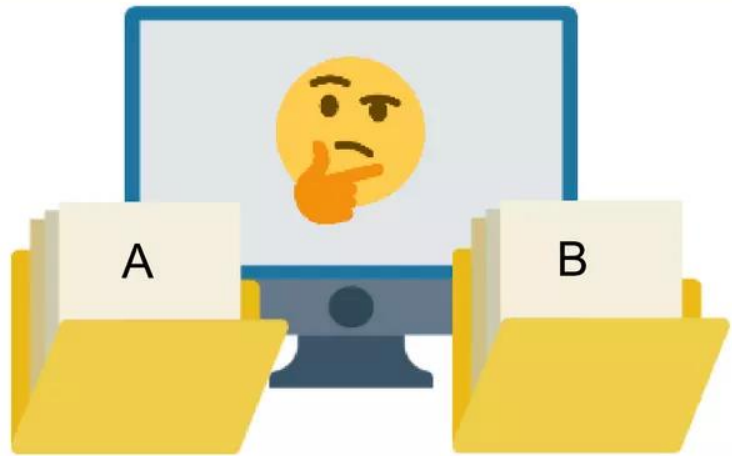
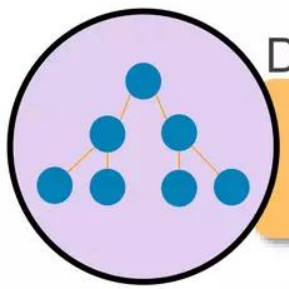
Solutions to Classification

A few Classification Solutions

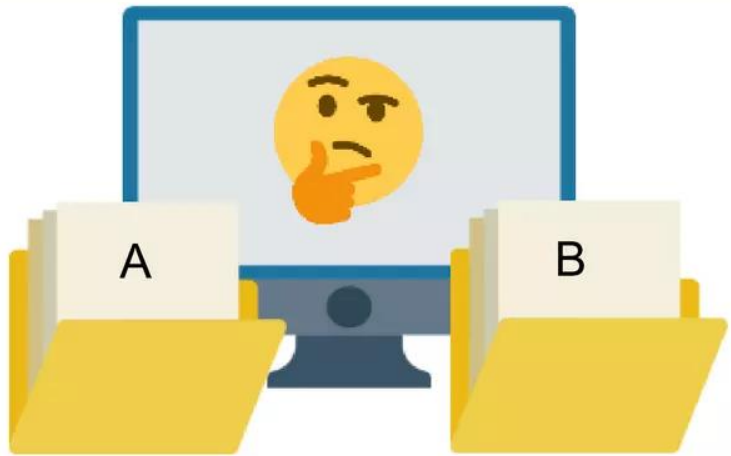




Decision Trees

We take decisions using a tree structure. Each branch node represents a choice, and leaf node represents a decision

A few Classification Solutions



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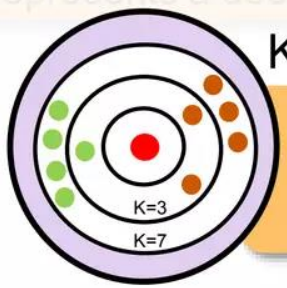
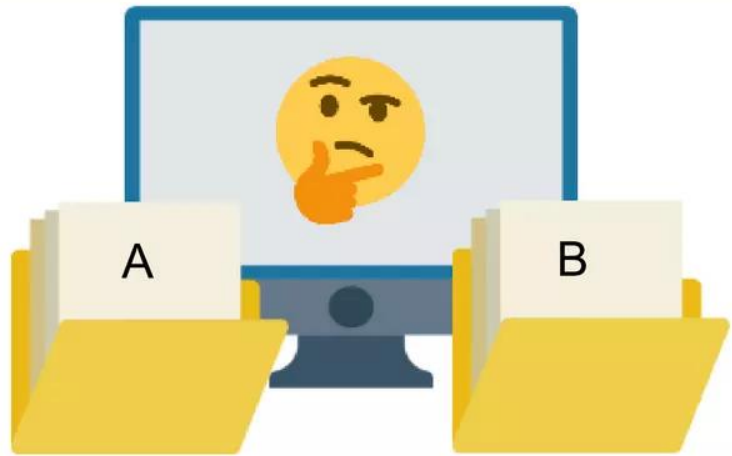
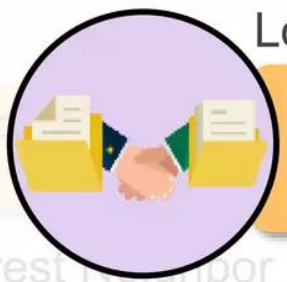


K-Nearest Neighbor

It helps determine what the given object is, based on its similarity to the objects it is compared to

A few Classification Solutions





Logistic Regression

A dataset with one or more independent variables is used to determine binary output of the dependent variable

Decision Trees

We determine the probability of an event occurring with the help of a tree structure

K-Nearest Neighbor

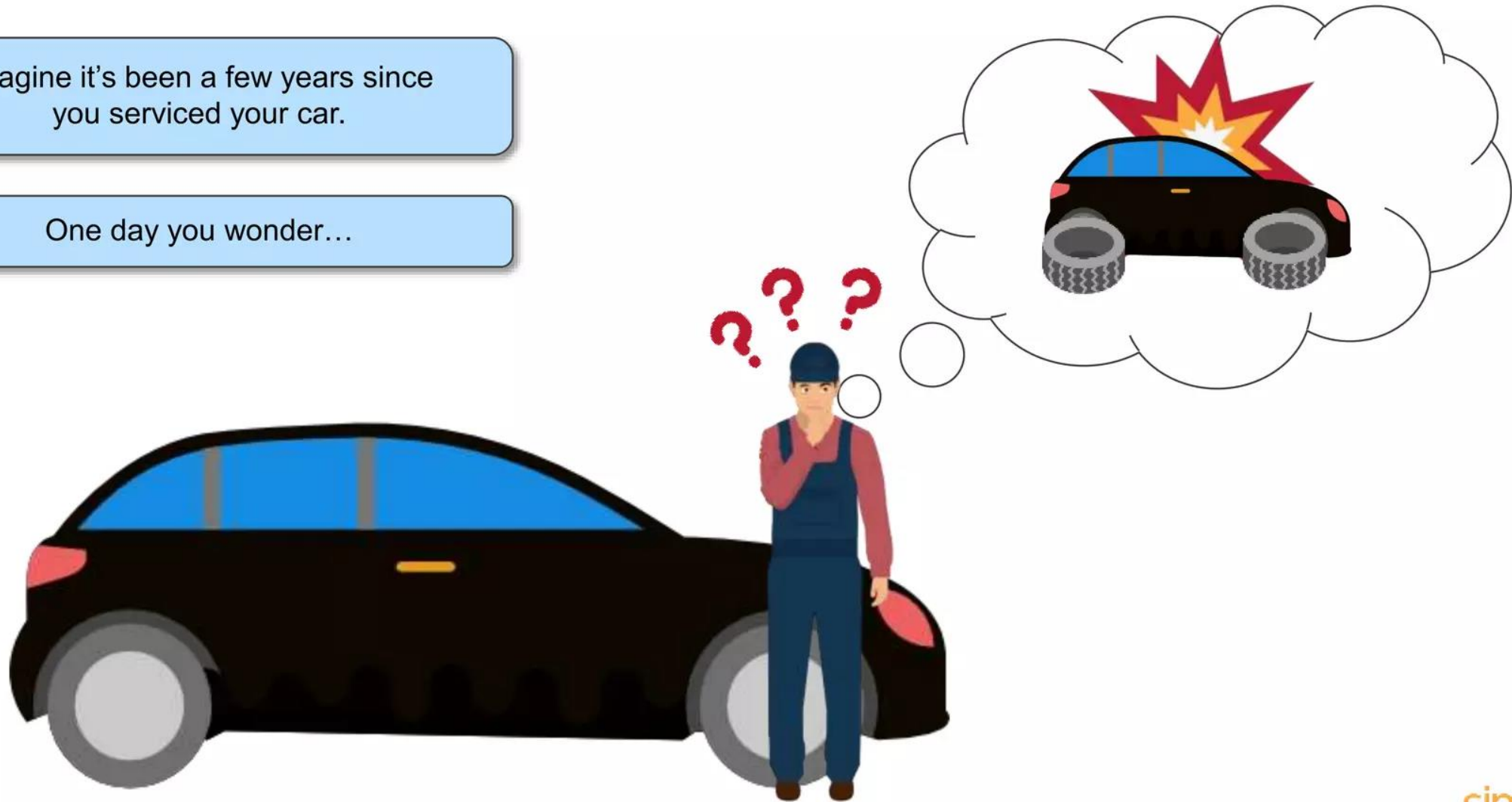
It helps determine what the given object is, based on its similarity to the objects it is compared to

What is Logistic Regression?

What is Logistic Regression?

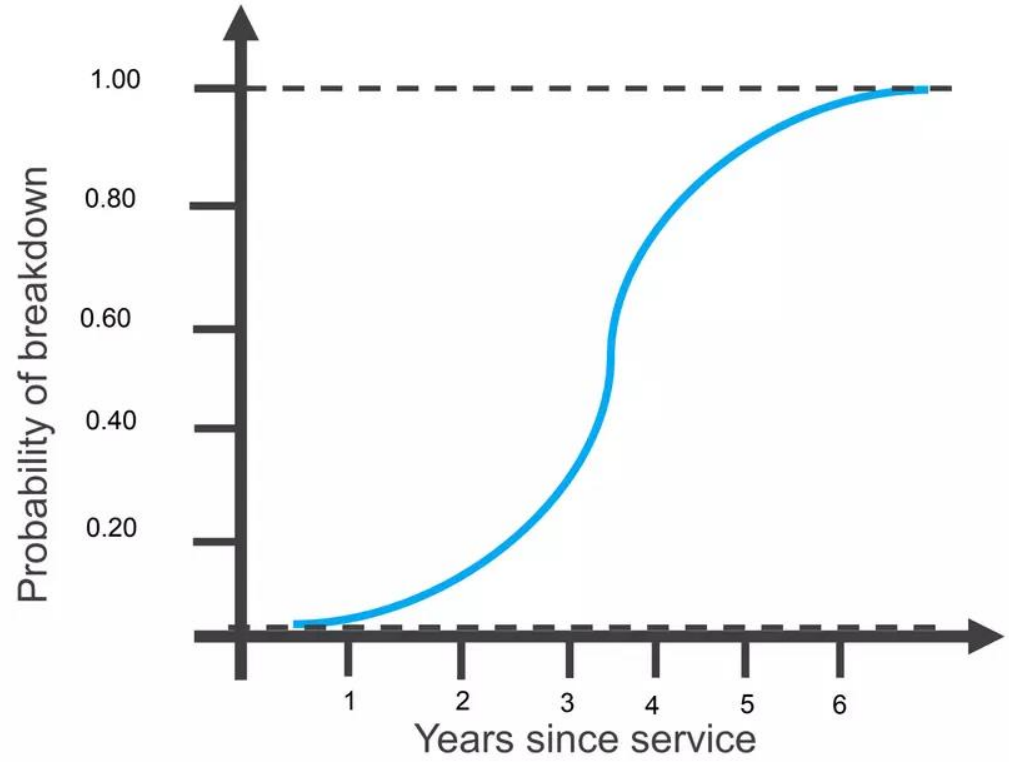
Imagine it's been a few years since you serviced your car.

One day you wonder…



What is Logistic Regression?

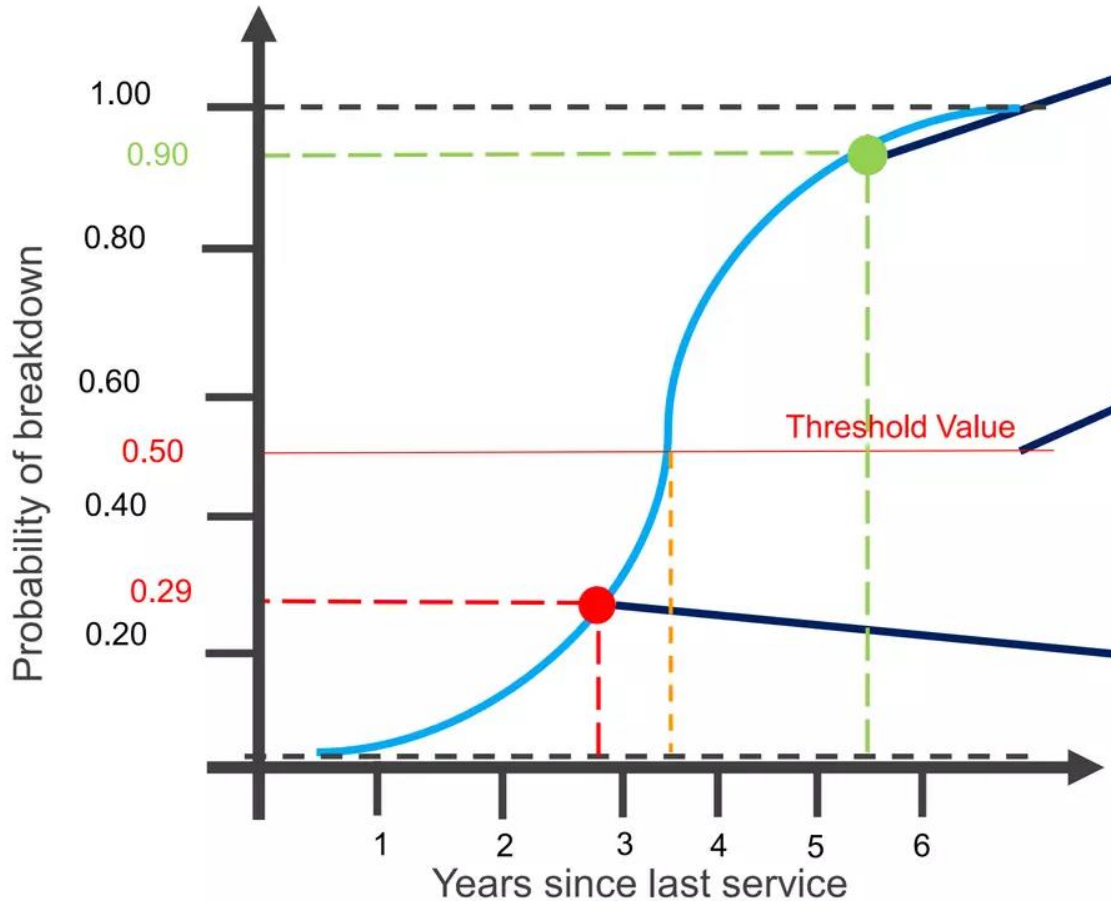
You provide years since last service



Regression model created based on other users' experience

It is a classification algorithm, used to predict binary outcomes for a given set of independent variables. The dependent variable's outcome is discrete.

What is Logistic Regression?



Probability>0.50
Value rounded off to 1 : The car will breakdown

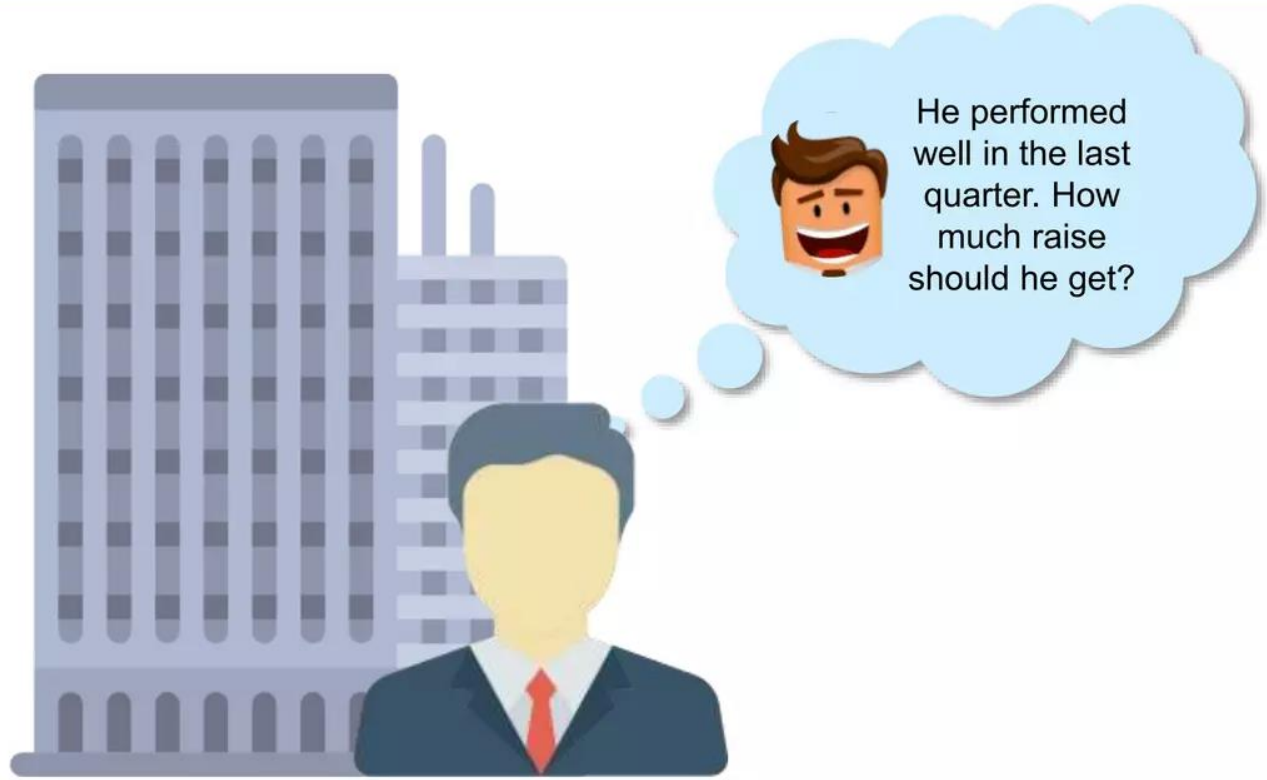
Here, the threshold value 0.50 indicates that the car is more likely to breakdown after 3.5 years of usage

Probability<0.50
Value rounded off to 0: The car will not breakdown

Model makes predictions

What is Linear Regression?

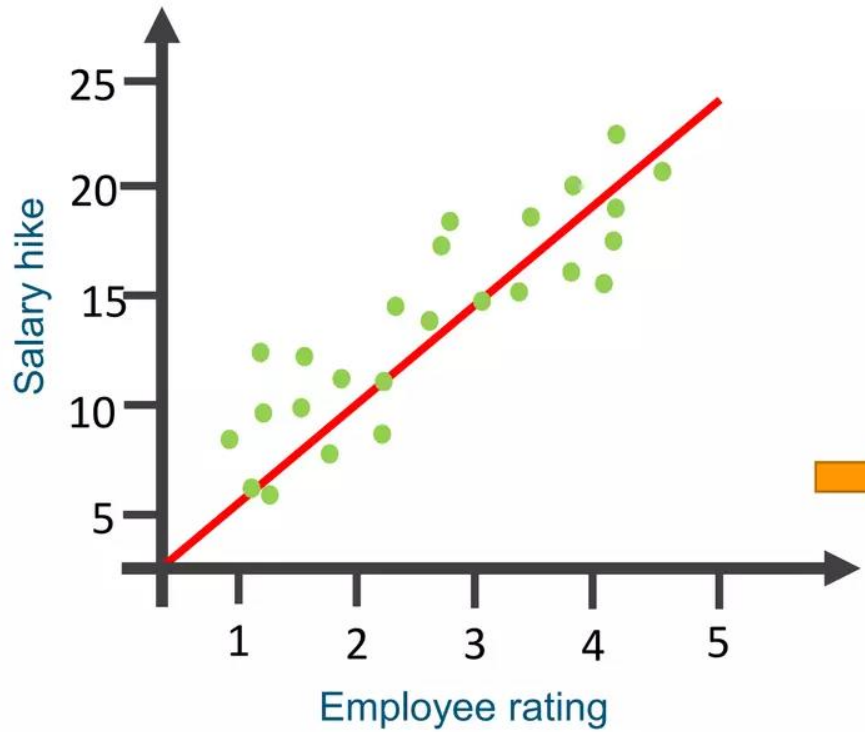
Linear Regression



It is a statistical method that helps find the relationship between an independent and dependent variable, both of which are continuous

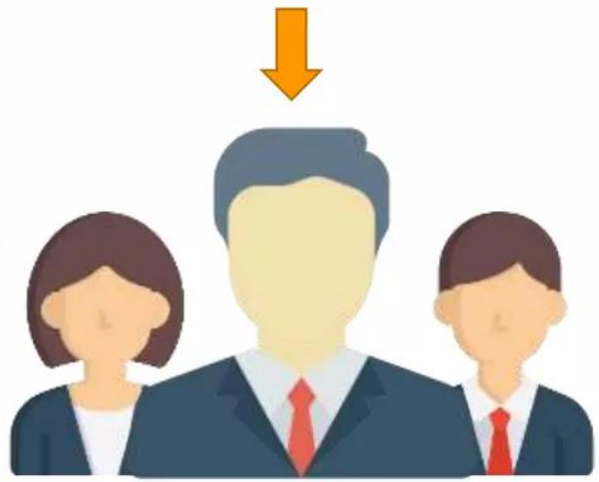
Linear Regression

Collection of ratings and corresponding hikes



Linear Regression is performed on data

Employee rating



The management provides the corresponding salary hike

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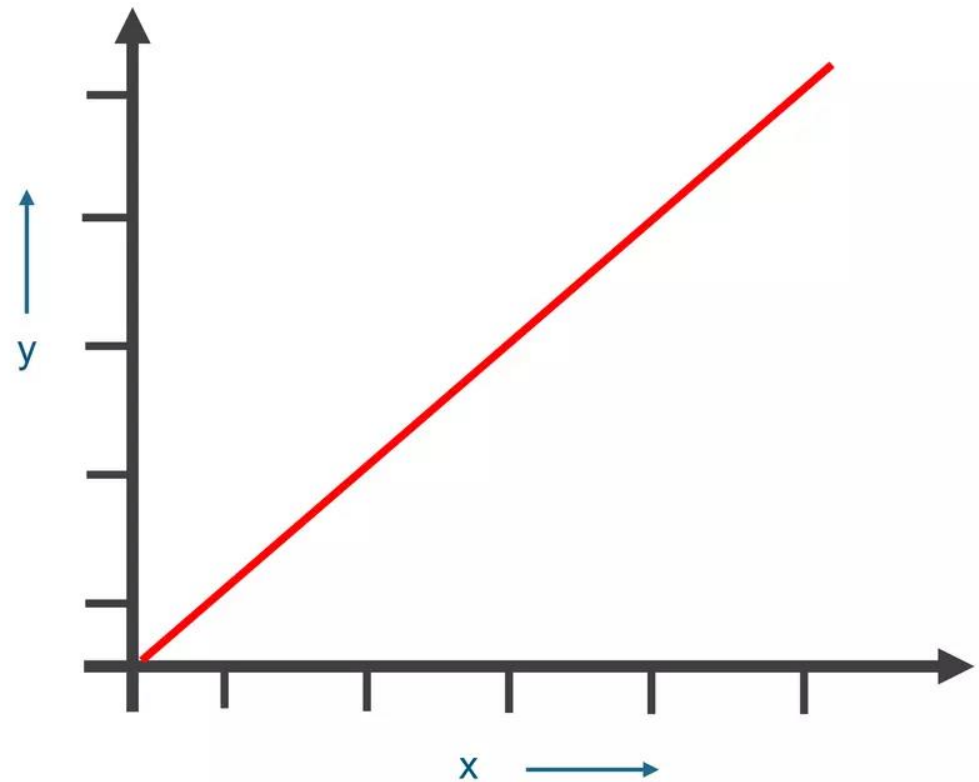
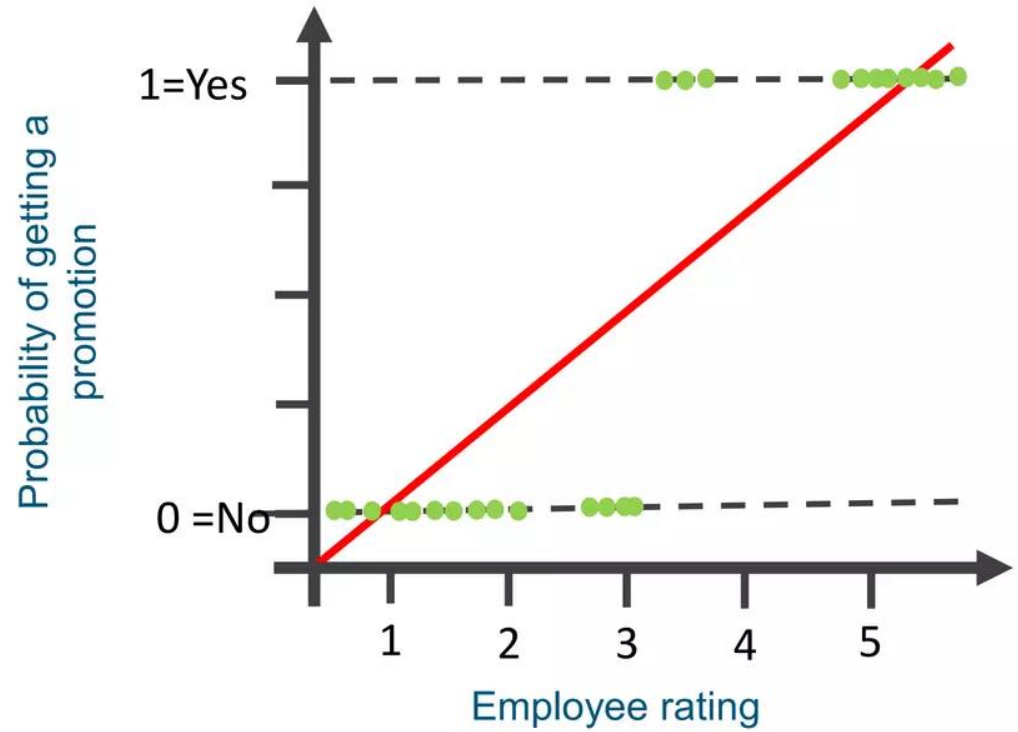
Linear and Logistic Regression

Here's the graph of how linear regression would be, for a given scenario



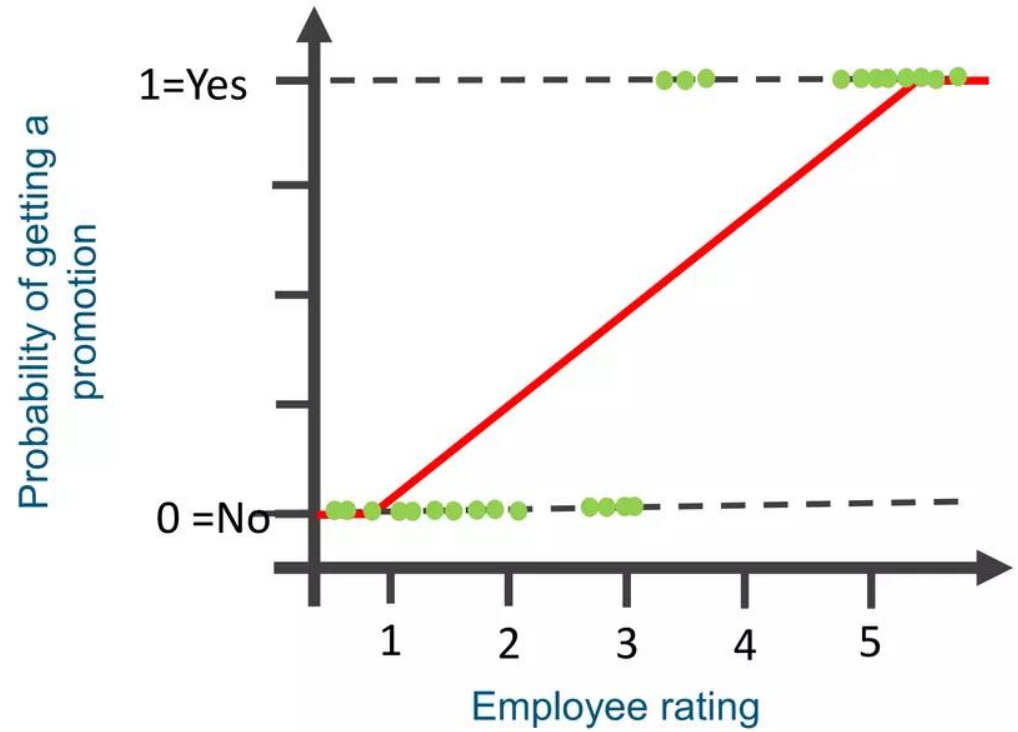
Linear and Logistic Regression

What if you wanted to know whether the employee would get a promotion or not based on their rating



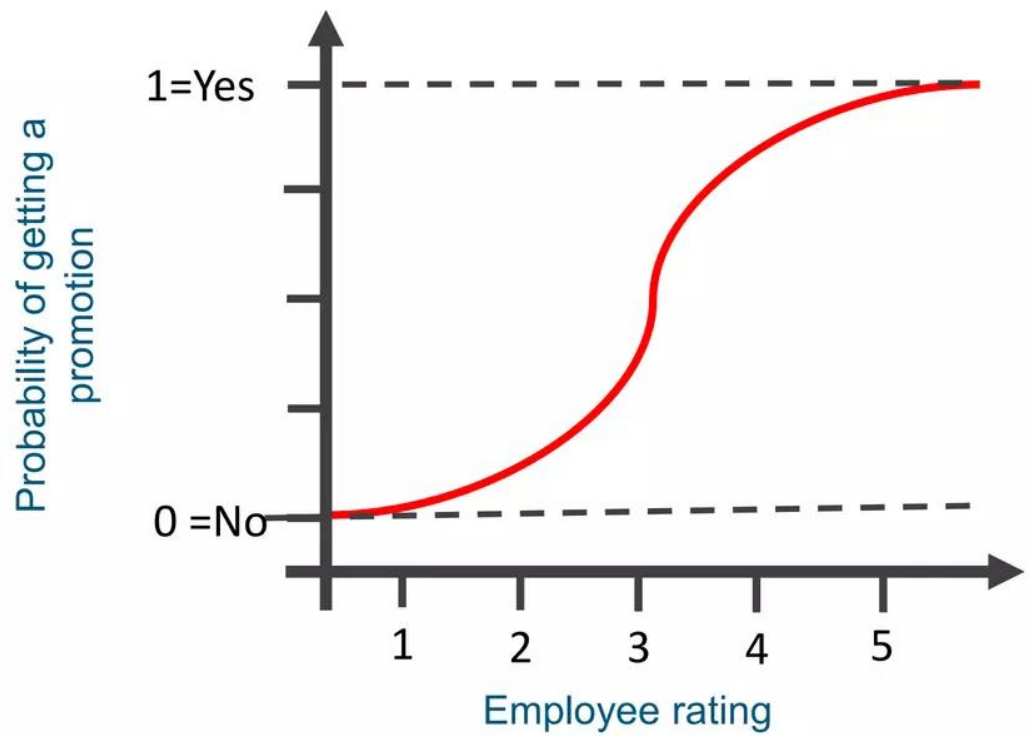
Linear and Logistic Regression

This graph would not be able to make such a prediction. So we clip the line at 0 and 1.



Linear and Logistic Regression

So, how did this…

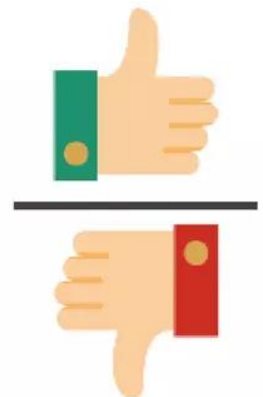


…become this?

The Math behind Logistic Regression

To understand Logistic Regression, let's talk about the odds of success

Odds (θ) =



$$\frac{\text{Probability of an event happening}}{\text{Probability of an event not happening}} \quad or \quad \theta = \frac{p}{1-p}$$

The values of odds range from 0 to ∞
The values of probability change from 0 to 1

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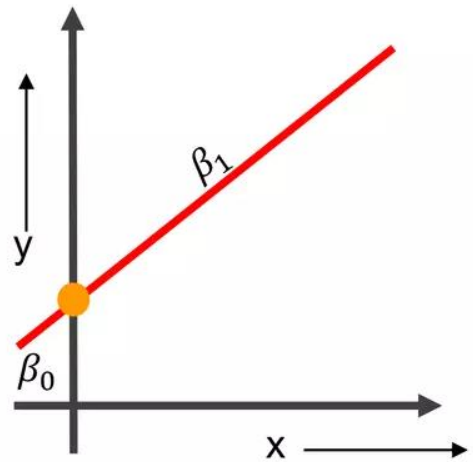
The Math behind Logistic Regression

Take the equation of the straight line



Here, β_0 is the y-intercept
β_1 is the slope of the line
x is the value of the x co-ordinate
y is the value of the prediction

The equation would be: $y = \beta_0 + \beta_1 x$

The Math behind Logistic Regression

Now, we predict the odds of success

$$\log\left(\frac{p(x)}{1-P(x)}\right) = \beta_0 + \beta_1 x$$

Exponentiating both sides:

$$e^{ln}\left(\frac{p(x)}{1-p(x)}\right) = e^{\beta_0+\beta_1 x}$$

$$\left(\frac{p(x)}{1-p(x)}\right) = e^{\beta_0+\beta_1 x}$$

Let Y = $e^{\beta_0+\beta_1 x}$

Then $\frac{p(x)}{1-p(x)} = Y$

$$p(x) = Y(1-p(x))$$
$$p(x) = Y - Y(p(x))$$
$$p(x) + Y(p(x)) = Y$$
$$p(x)(1+Y) = Y$$
$$p(x) = \frac{Y}{1+Y}$$
$$p(x) = \frac{e^{\beta_0+\beta_1 x}}{1+e^{\beta_0+\beta_1 x}}$$

The equation of a sigmoid function:

$$p(x) = \frac{e^{\beta_0+\beta_1 x}}{1+e^{\beta_0+\beta_1 x}}$$

$$p(x) = \frac{1}{1+e^{-(\beta_0+\beta_1 x)}}$$

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The Math behind Logistic Regression

A sigmoid curve is obtained!

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Comparing Linear and Logistic Regression

How is Linear and Logistic Regression different?

Linear Regression

- Used to solve Regression Problems

Logistic Regression

How is Linear and Logistic Regression different?

Linear Regression

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Logistic Regression

- Used to solve Classification Problems

How is Linear and Logistic Regression different?

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- The response variables are continuous in nature

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How is Linear and Logistic Regression different?

Linear Regression

- Used to solve Regression Problems
- The response variables are continuous in nature
- It helps estimate the dependent variable when there is a change in the independent variable.

Logistic Regression

- Used to solve Classification Problems
- The response variable is categorical in nature

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- It helps calculate the possibility of a particular event taking place.

How is Linear and Logistic Regression different?

Linear Regression

- Used to solve Regression Problems
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- Is a straight line.

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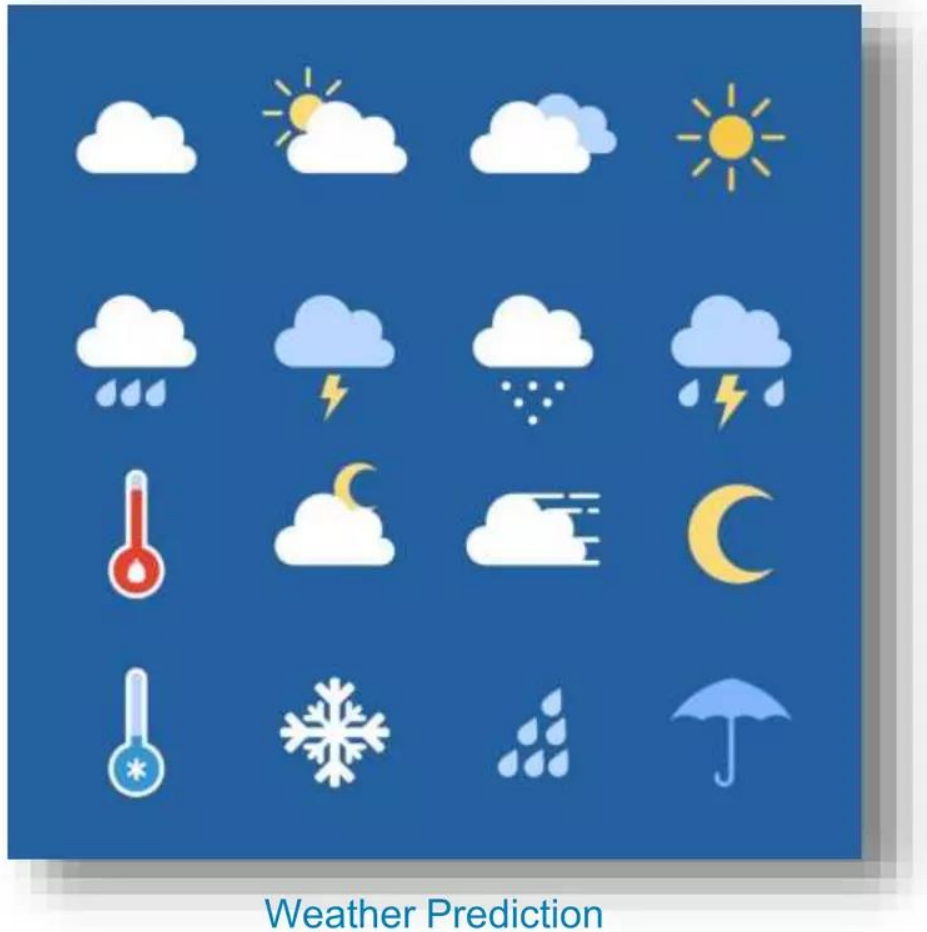
Logistic Regression

- Used to solve Classification Problems
- The response variable is categorical in nature
- It helps calculate the possibility of a particular event taking place.

- An S-curve. (S = Sigmoid)

Logistic Regression Applications



Weather Prediction

Helps determine the kind of weather that can be expected

Logistic Regression Applications

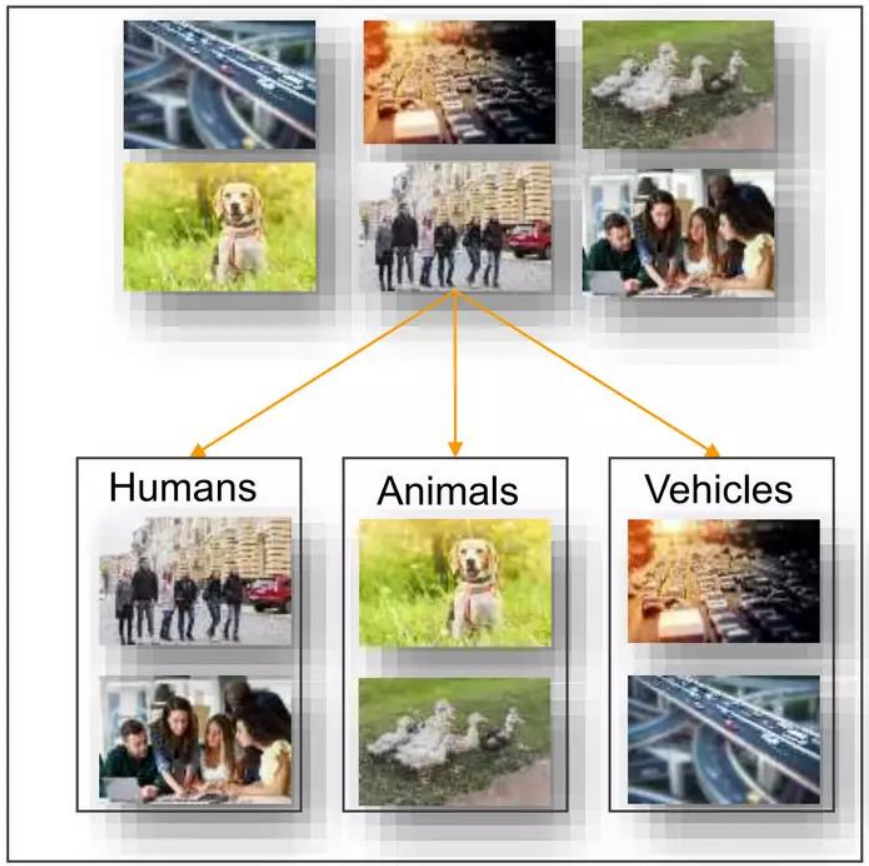
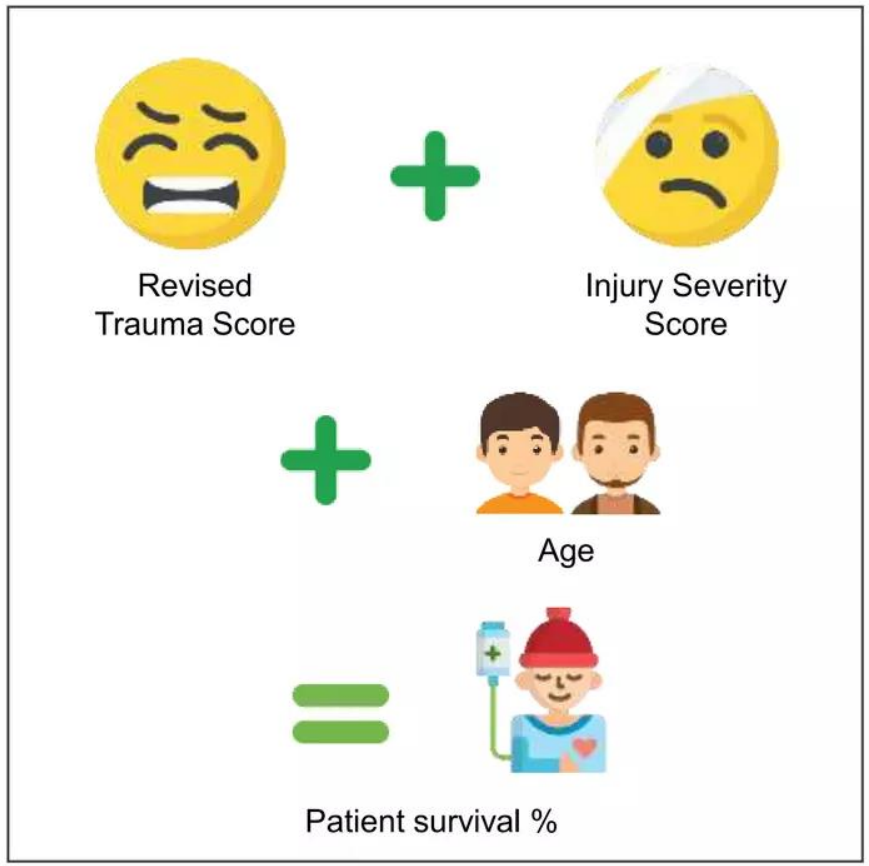


Image Categorization

Identifies the different components that are present in the image, and helps categorize them

Logistic Regression Applications

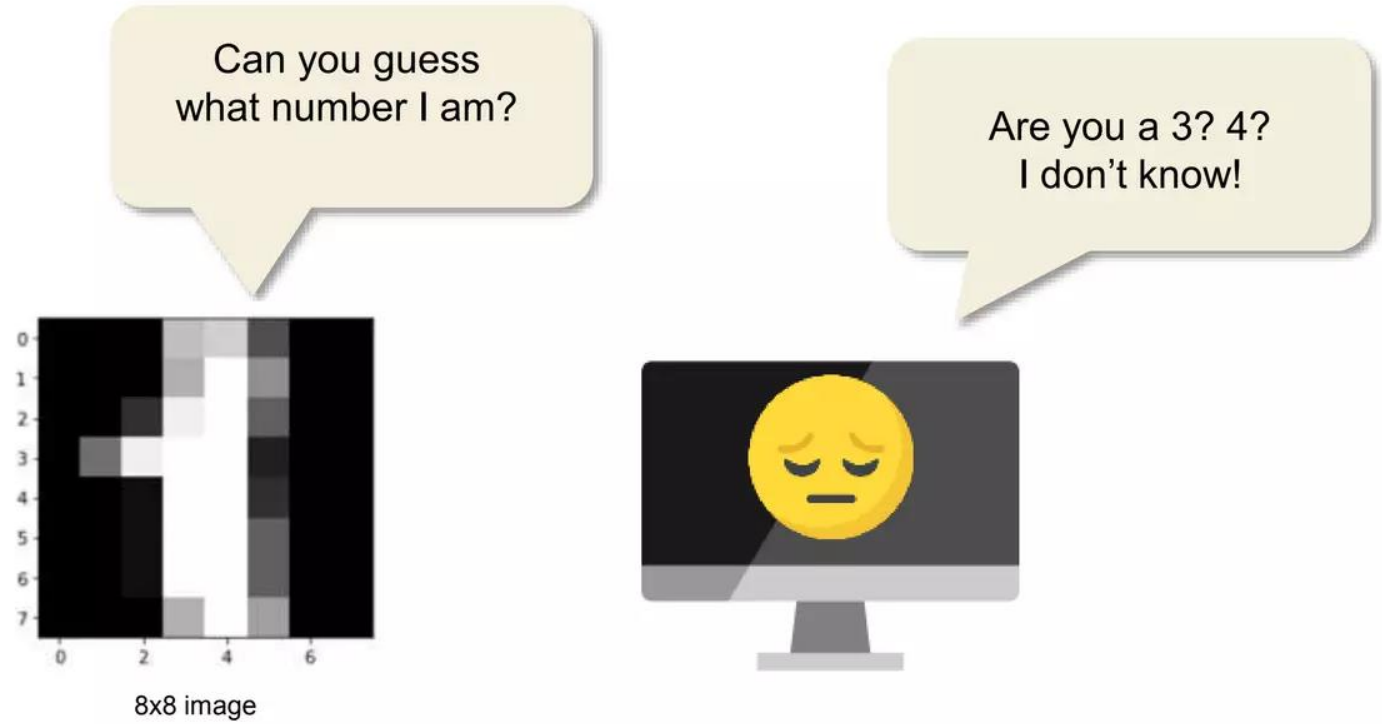


Healthcare (TRISS)

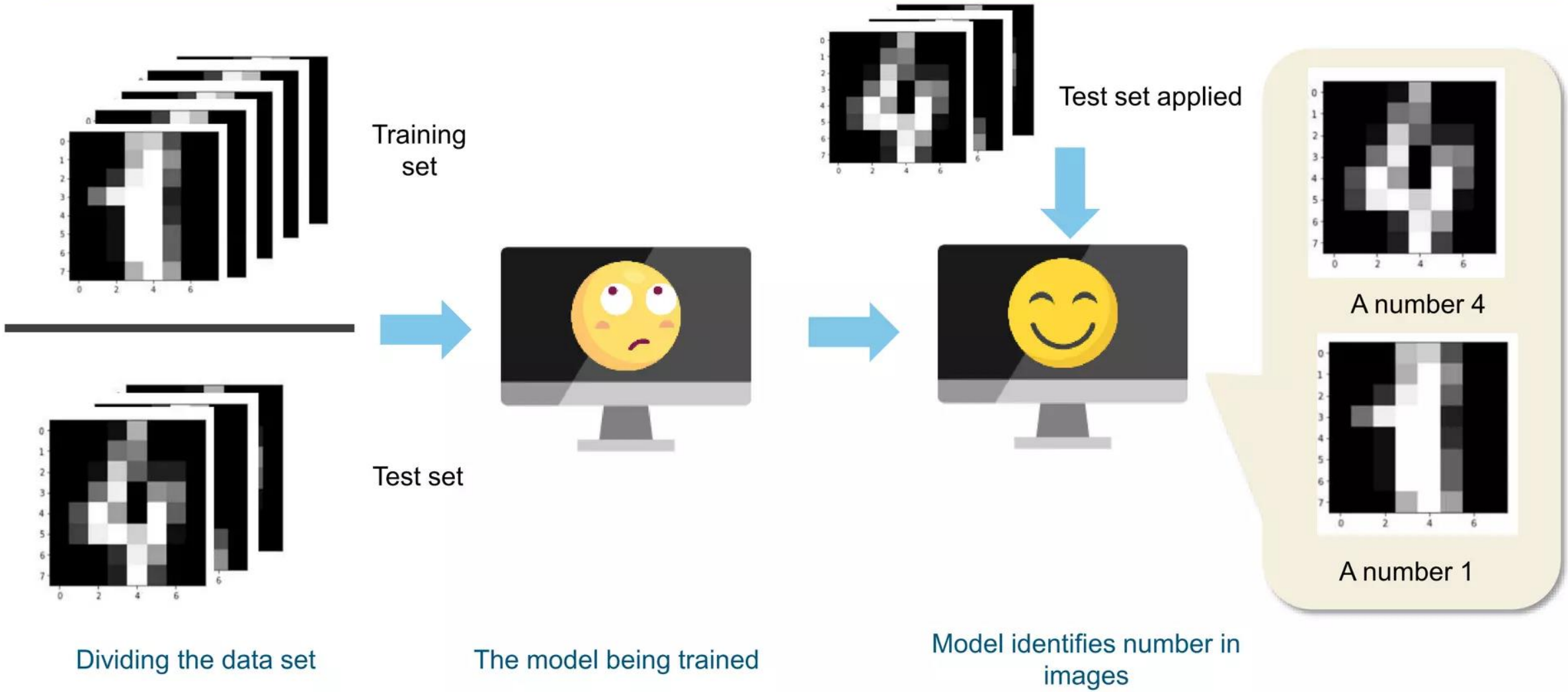
Determines the possibility of patient survival, taking age, ISS and RTS into consideration

Use Case – Predicting numbers in images

Use Case – Predicting numbers



Use Case – Predicting numbers



Use Case – Implementation

Importing libraries and their associated methods

```
from sklearn.datasets import load_digits
from sklearn.model_selection import train_test_split
import numpy as np

import matplotlib.pyplot as plt
import seaborn as sns
from sklearn import metrics
%matplotlib inline
digits = load_digits()
```

Determining the total number of images and labels

```
print("Image Data Shape", digits.data.shape)
print("Label Data Shape", digits.target.shape)
```

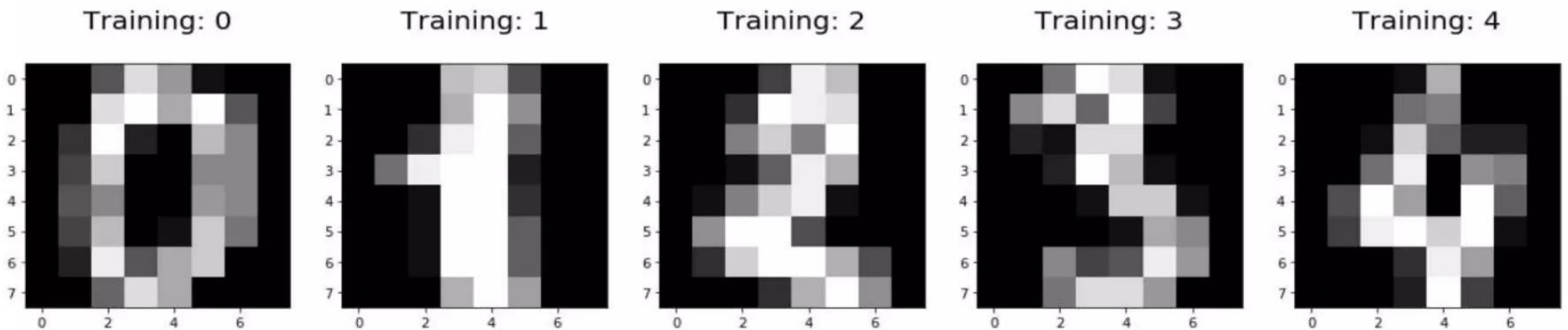
```
Image Data Shape (1797, 64)
Label Data Shape (1797,)
```

Use Case – Implementation

Displaying some of the images and labels

```
import numpy as np
import matplotlib.pyplot as plt

plt.figure(figsize=(20,4))
for index, (image, label) in enumerate(zip(digits.data[0:5], digits.target[0:5])):
 plt.subplot(1, 5, index + 1)
 plt.imshow(np.reshape(image, (8,8)), cmap=plt.cm.gray)
 plt.title('Training: %i\n' % label, fontsize = 20)
```



Use Case – Implementation

Dividing dataset into Training and Test set

```
from sklearn.model_selection import train_test_split
x_train, x_test, y_train, y_test = train_test_split(digits.data, digits.target, test_size=0.23, random_state=2)
```

```
print(x_train.shape)
```

```
(1383, 64)
```

```
print(y_train.shape)
```

```
(1383,)
```

```
print(x_test.shape)
```

```
(414, 64)
```

```
print(y_test.shape)
```

```
(414,)
```

Use Case – Implementation

Import the Logistic Regression model

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

Making an instance of the model and training it

```
logisticRegr = LogisticRegression()
logisticRegr.fit(x_train, y_train)
```

```
LogisticRegression(C=1.0, class_weight=None, dual=False, fit_intercept=True,
          intercept_scaling=1, max_iter=100, multi_class='ovr', n_jobs=1,
          penalty='l2', random_state=None, solver='liblinear', tol=0.0001,
          verbose=0, warm_start=False)
```

Predicting the output of the first element of the test set

```
print(logisticRegr.predict(x_test[0].reshape(1,-1)))
```

```
[4]
```

Predicting the output of the first 10 elements of the test set

```
logisticRegr.predict(x_test[0:10])
```

```
array([4, 0, 9, 1, 8, 7, 1, 5, 1, 6])
```

Use Case – Implementation

Predicting for the entire dataset

```
predictions = logisticRegr.predict(x_test)
```

Determining the accuracy of the model

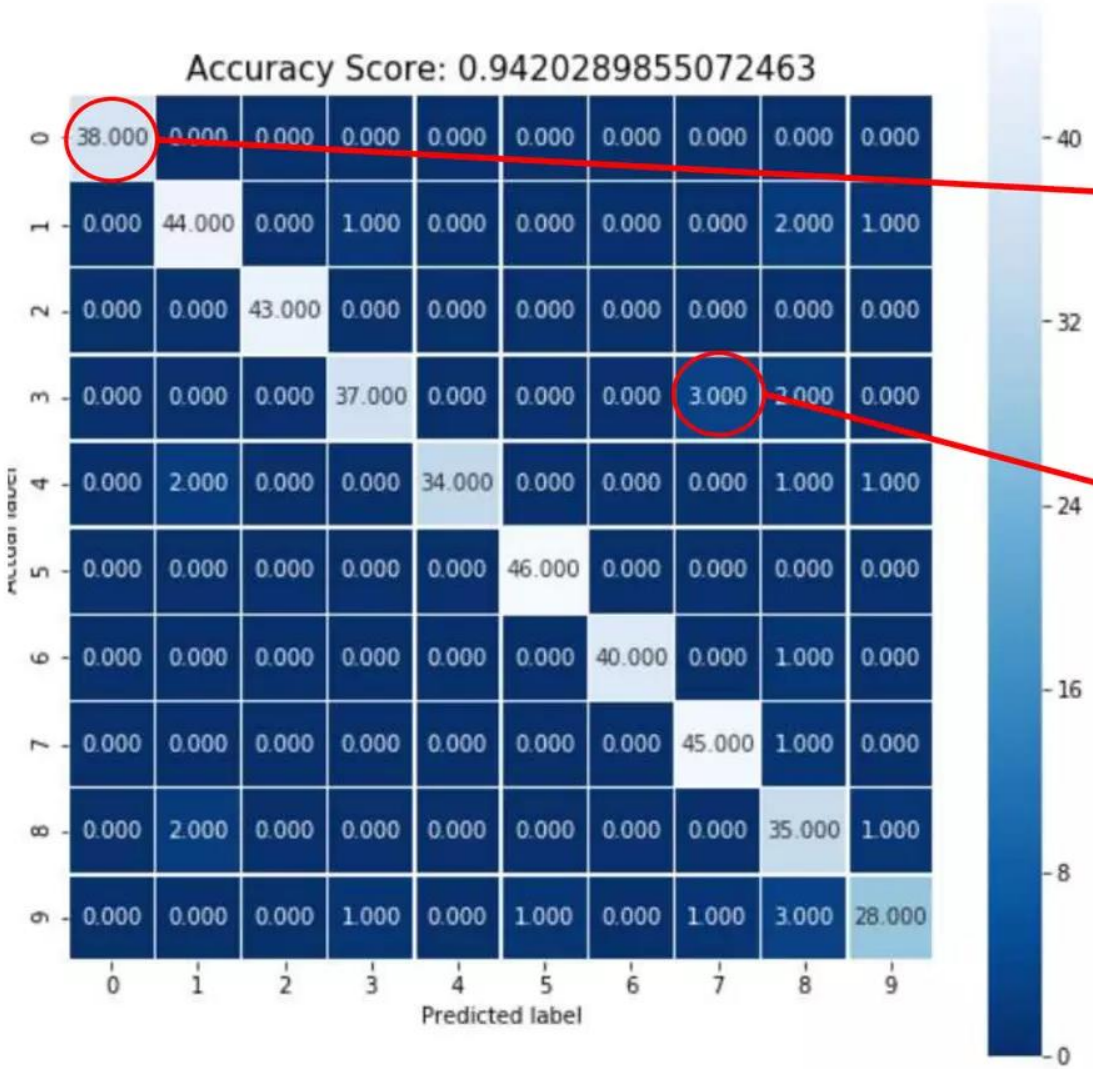
```
score = logisticRegr.score(x_test, y_test)
print(score)
```

```
0.9420289855072463
```

Representing the confusion matrix in a heat map

```
plt.figure(figsize=(9,9))
sns.heatmap(cm, annot=True, fmt=".3f", linewidths=.5, square = True, cmap = 'Blues_r');
plt.ylabel('Actual label');
plt.xlabel('Predicted label');
all_sample_title = 'Accuracy Score: {0}'.format(score)
plt.title(all_sample_title, size = 15);
```

Use Case – Implementation



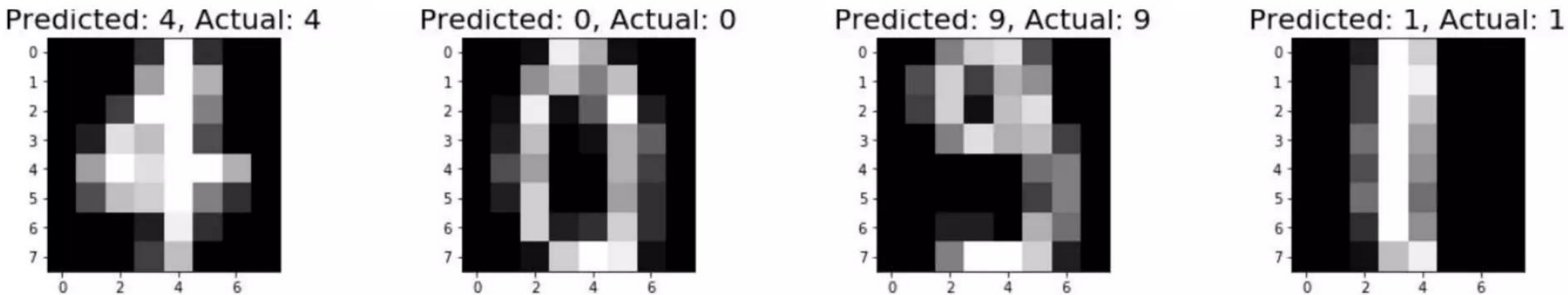
Accurately predicting the image to contain a zero

Inaccurately predicting the image to contain a seven

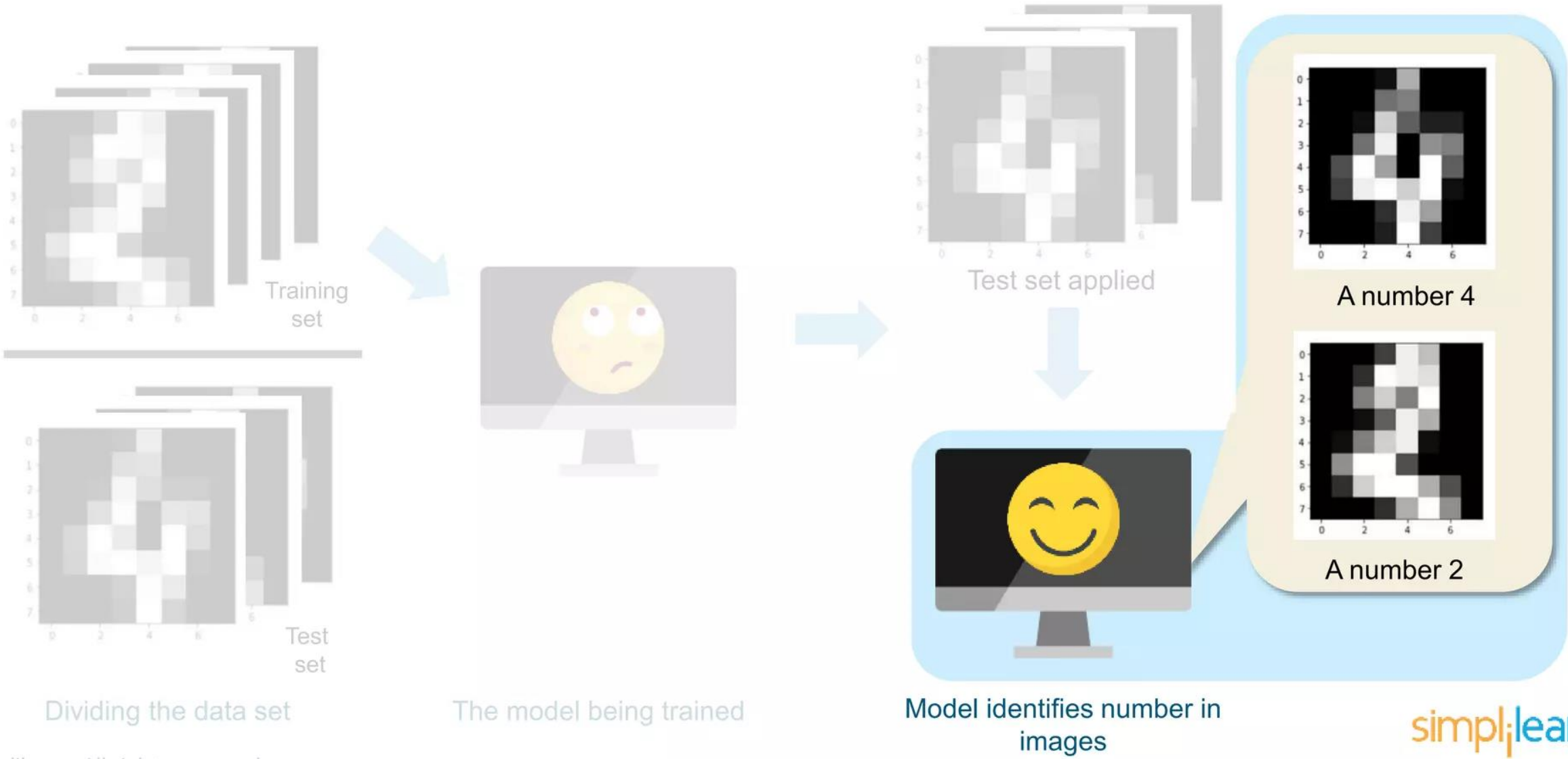
Use Case – Implementation

Presenting predictions and actual output

```
index = 0
misclassifiedIndex = []
for predict, actual in zip(predictions, y_test):
    if predict==actual:
        misclassifiedIndex.append(index)
    index +=1
plt.figure(figsize=(20,3))
for plotIndex, wrong in enumerate(misclassifiedIndex[0:4]):
    plt.subplot(1,4, plotIndex +1)
    plt.imshow(np.reshape(x_test[wrong], (8,8)),cmap=plt.cm.gray)
    plt.title("Predicted: {}, Actual: {}" .format(predictions[wrong], y_test[wrong]), fontsize=20)
```



Use Case – Predicting numbers



Here's What You've Learnt so Far