```
##L2 Level 2 Given a data set from UCI repository, implement the
##Logistic regression algorithm. Estimate the class probabilities for a given
##test data set. Plot and analyze the decision boundaries.
```

```
from sklearn.linear_model import LogisticRegression
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd
from sklearn.preprocessing import StandardScaler
```

```
url = "https://archive.ics.uci.edu/ml/machine-learning-databases/wine-quality/winequality-white.csv"
data = pd.read_csv(url, sep=';')
data
```

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	quality
0	7.0	0.27	0.36	20.7	0.045	45.0	170.0	1.00100	3.00	0.45	8.8	6
1	6.3	0.30	0.34	1.6	0.049	14.0	132.0	0.99400	3.30	0.49	9.5	6
2	8.1	0.28	0.40	6.9	0.050	30.0	97.0	0.99510	3.26	0.44	10.1	6
3	7.2	0.23	0.32	8.5	0.058	47.0	186.0	0.99560	3.19	0.40	9.9	6
4	7.2	0.23	0.32	8.5	0.058	47.0	186.0	0.99560	3.19	0.40	9.9	6
...	...	...	...	...	...	...	...	...	...	...	...	...
4893	6.2	0.21	0.29	1.6	0.039	24.0	92.0	0.99114	3.27	0.50	11.2	6
4894	6.6	0.32	0.36	8.0	0.047	57.0	168.0	0.99490	3.15	0.46	9.6	5
4895	6.5	0.24	0.19	1.2	0.041	30.0	111.0	0.99254	2.99	0.46	9.4	6
4896	5.5	0.29	0.30	1.1	0.022	20.0	110.0	0.98869	3.34	0.38	12.8	7
4897	6.0	0.21	0.38	0.8	0.020	22.0	98.0	0.98941	3.26	0.32	11.8	6

4898 rows × 12 columns

```
# Define the features and target variables
X = data.drop('quality', axis=1) ##independent variables
y = data['quality'] ## dependent variable
```

```
data['quality'].value_counts()
```

```
6    2198
5    1457
7     880
8     175
4     163
3      20
9       5
Name: quality, dtype: int64
```

```
# Split the data into training and test sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2,random_state=42)
```

```
# Create the logistic regression model
model = LogisticRegression()
# Train the model on the training data
model.fit(X_train, y_train)
# Predict the target variable for the test data
y_pred = model.predict(X_test)
# Estimate the class probabilities for the test data
probas = model.predict_proba(X_test)
print(probas)
```

```
[[6.56091920e-03 5.13396070e-03 1.57290170e-01 ... 2.22603246e-01
  4.47574855e-02 1.16089350e-03]
 [2.88931485e-03 1.54392445e-02 7.31896407e-02 ... 3.69900579e-01
  3.87504736e-02 1.20412376e-03]
 [3.10953069e-03 2.68482195e-02 1.75970288e-01 ... 2.44565419e-01
```

```
  3.51008124e-02 1.43801044e-03]
 ...
 [1.95111287e-03 1.91795020e-02 3.10606599e-01 ... 1.36821378e-01
  2.84953856e-02 5.48167478e-04]
 [6.41134849e-04 5.80278228e-02 5.02127034e-01 ... 7.00609475e-02
  1.50932087e-02 2.81565458e-04]
 [1.58404495e-03 8.10818684e-02 3.78712328e-01 ... 1.18690161e-01
  2.75177607e-02 5.22535496e-04]]
/usr/local/lib/python3.10/dist-packages/sklearn/linear_model/_logistic.py:458: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  n_iter_i = _check_optimize_result(
```

```
# Print the accuracy score for the model
accuracy = accuracy_score(y_test, y_pred)
print("Accuracy: ", accuracy)
```

```
Accuracy:  0.45918367346938777
```

```
# Create a meshgrid for all 11 features
x_min, x_max = X.iloc[:, 0].min() - 1, X.iloc[:, 0].max() + 1
y_min, y_max = X.iloc[:, 1].min() - 1, X.iloc[:, 1].max() + 1
xx, yy = np.meshgrid(np.arange(x_min, x_max, 0.1),
                     np.arange(y_min, y_max, 0.1))
for i in range(2, 12):
    plt.subplot(3, 4, i-1)
    plt.subplots_adjust(wspace=0.5, hspace=0.4)

    X_plot = np.zeros((xx.shape[0] * xx.shape[1], 11))
    X_plot[:, 0] = xx.ravel()
    X_plot[:, 1] = yy.ravel()

    for j in range(2, 12):
        if i != j:
            X_plot[:, j-1] = X[X.columns[j-1]].mean()

    Z = model.predict_proba(X_plot)[:, 1]
    Z = Z.reshape(xx.shape)

    # Plot the decision boundaries as a contour plot
    plt.contourf(xx, yy, Z, alpha=0.4)
    plt.colorbar()

    # Plot the data points on top of the decision boundaries
    plt.scatter(X.iloc[:, i-2], X.iloc[:, i-1], c=y, alpha=0.8)
    plt.xlabel(X.columns[i-2])
    plt.ylabel(X.columns[i-1])

plt.show()
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:439: UserWarning: X does not have valid feature names, but Logistic
  warnings.warn(
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:439: UserWarning: X does not have valid feature names, but Logistic
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  warnings.warn(
```

```
## Using 2 variables winequality-red.csv
```

```
# Load winequality dataset
df = pd.read_csv("https://archive.ics.uci.edu/ml/machine-learning-databases/wine-quality/winequality-red.csv", delimiter=";")
df
```

	fixed acidity	volatile acidity	citric acid	residual sugar	chlorides	free sulfur dioxide	total sulfur dioxide	density	pH	sulphates	alcohol	quality
0	7.4	0.700	0.00	1.9	0.076	11.0	34.0	0.99780	3.51	0.56	9.4	5
1	7.8	0.880	0.00	2.6	0.098	25.0	67.0	0.99680	3.20	0.68	9.8	5
2	7.8	0.760	0.04	2.3	0.092	15.0	54.0	0.99700	3.26	0.65	9.8	5
3	11.2	0.280	0.56	1.9	0.075	17.0	60.0	0.99800	3.16	0.58	9.8	6
4	7.4	0.700	0.00	1.9	0.076	11.0	34.0	0.99780	3.51	0.56	9.4	5
...	...	...	...	...	...	...	...	...	...	...	...	...
1594	6.2	0.600	0.08	2.0	0.090	32.0	44.0	0.99490	3.45	0.58	10.5	5
1595	5.9	0.550	0.10	2.2	0.062	39.0	51.0	0.99512	3.52	0.76	11.2	6
1596	6.3	0.510	0.13	2.3	0.076	29.0	40.0	0.99574	3.42	0.75	11.0	6
1597	5.9	0.645	0.12	2.0	0.075	32.0	44.0	0.99547	3.57	0.71	10.2	5
1598	6.0	0.310	0.47	3.6	0.067	18.0	42.0	0.99549	3.39	0.66	11.0	6

1599 rows × 12 columns

```
print(df.columns)
```

```
Index(['fixed acidity', 'volatile acidity', 'citric acid', 'residual sugar',
       'chlorides', 'free sulfur dioxide', 'total sulfur dioxide', 'density',
       'pH', 'sulphates', 'alcohol', 'quality'],
      dtype='object')
```

```
# Split data into training and testing sets
X = df.drop(columns=['fixed acidity', 'citric acid', 'residual sugar','chlorides', 'free sulfur dioxide', 'total sulfur dioxide', 'density','
y = df['quality']
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=42)
```

```
# Train logistic regression model
lr = LogisticRegression(solver='lbfgs', multi_class='auto', max_iter=1000)
lr.fit(X_train, y_train)
```

```
▾       LogisticRegression
LogisticRegression(max_iter=1000)
```

```
# Print classification report
from sklearn.metrics import classification_report
y_pred = lr.predict(X_test)
print(classification_report(y_test, y_pred))
```

```
              precision    recall  f1-score   support

           3       0.00      0.00      0.00         1
           4       0.00      0.00      0.00        10
           5       0.59      0.78      0.67       130
           6       0.52      0.50      0.51       132
           7       0.37      0.17      0.23        42
           8       0.00      0.00      0.00         5

    accuracy                           0.55       320
   macro avg       0.25      0.24      0.24       320
weighted avg       0.50      0.55      0.51       320

/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: UndefinedMetricWarning: Precision and F-score are ill-c
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: UndefinedMetricWarning: Precision and F-score are ill-c
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.10/dist-packages/sklearn/metrics/_classification.py:1344: UndefinedMetricWarning: Precision and F-score are ill-c
  _warn_prf(average, modifier, msg_start, len(result))
```

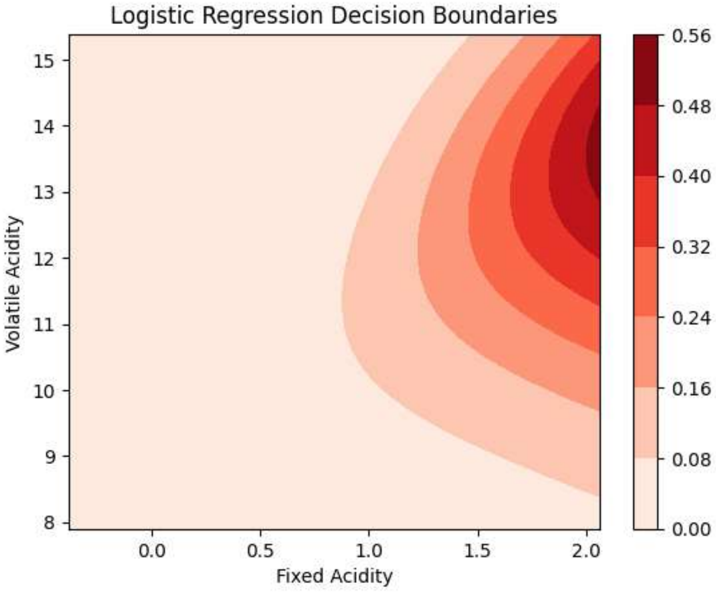
```
# Plot decision boundaries
n_classes = len(np.unique(y_train))
plot_colors = "ryb"
plot_step = 0.02
x_min, x_max = X.iloc[:, 0].min() - 0.5, X.iloc[:, 0].max() + 0.5
y_min, y_max = X.iloc[:, 1].min() - 0.5, X.iloc[:, 1].max() + 0.5
xx, yy = np.meshgrid(np.arange(x_min, x_max, plot_step), np.arange(y_min, y_max, plot_step))

Z = lr.predict_proba(np.c_[xx.ravel(), yy.ravel()])
Z = Z[:, 1].reshape(xx.shape)

cs = plt.contourf(xx, yy, Z, cmap=plt.cm.Reds)
plt.colorbar(cs)

plt.xlabel("Fixed Acidity")
plt.ylabel("Volatile Acidity")
plt.title("Logistic Regression Decision Boundaries")
plt.show()
```

```
/usr/local/lib/python3.10/dist-packages/sklearn/base.py:439: UserWarning: X does not hav
  warnings.warn(
```


Logistic Regression Decision Boundaries
Volatile Acidity
Fixed Acidity