experiment_5

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1 Experiment 5

1.1 5 January

2 24MDT0184

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3 Softmax Regression

3.1 Q1. Today we will try to implement softmax regression for solving a multiclass classification problem. For that lets create a synthetic dataset using the make classification function that we used in the previous class. Lets assume we have two features X1 and X2 to predict three classes to which they belong to. And try to plot the decision boundaries in that cases.

- First lets try to create a dataset for our purpose

[41]:
```
import numpy as np
import pandas as pd
from sklearn.datasets import make_classification
import matplotlib.pyplot as plt
x, y = make_classification(n_classes = 3, n_features = 2, n_redundant = 0,␣
 ↪n_clusters_per_class = 1, random_state = 42)
```

[42]:
```
x
```

[42]:
```
array([[ 0.69840909, -1.38029525],
       [-0.00832267, -1.7576143 ],
       [ 1.12991576,  1.10236134],
       [ 1.22831184, -0.75717844],
       [-1.37298251, -1.73833907],
       [-1.36670344, -1.71586731],
       [-0.22550626, -0.18453596],
       [ 0.806865  ,  0.83434332],
       [ 1.03307436, -0.85545993],
       [ 1.48828894,  1.53392072],
       [ 0.58590018, -1.33745666],
       [-0.76688721, -0.55254337],
```

```
[ 0.63356167, -1.17278867],
[ 0.12437227,  0.19896733],
[-0.42860597,  0.15025667],
[ 1.32272135, -0.59340317],
[-0.08239154, -0.02861137],
[-0.949498  , -0.92631465],
[ 1.1589004 ,  1.12625638],
[ 1.00183089, -1.02646717],
[ 1.8394635 ,  1.80773058],
[ 0.55656344, -1.31038476],
[ 0.76916909, -1.0609667 ],
[ 0.46010921, -1.48739641],
[-0.76472142, -0.52767662],
[ 1.09563437,  1.04903808],
[-0.75106561, -0.50023377],
[ 1.88782031, -0.36699364],
[-0.90934319, -0.81098167],
[-0.83072007, -0.65732502],
[ 0.47335819, -1.43862044],
[-1.25518804, -1.4971788 ],
[ 0.094903  ,  0.09090508],
[ 0.73902766,  0.82180719],
[ 1.8935669 , -0.36699918],
[ 1.61550606, -0.57301231],
[-0.74449624, -0.49920984],
[ 1.39941898,  1.37486855],
[-0.85222618, -0.67499113],
[ 1.09821151,  1.1046981 ],
[ 1.71073996,  1.56900774],
[-1.02040828, -1.03271373],
[ 0.29376129,  0.32507268],
[ 0.08385789,  0.13140473],
[ 1.86077688,  1.77118957],
[-0.58577566, -0.40238862],
[ 3.07317945,  2.84564176],
[-0.93240288, -0.87686591],
[-1.24738177, -1.506883  ],
[-0.78652903, -0.5791034 ],
[ 1.29021194, -0.76408578],
[-0.95657393, -0.92833921],
[ 2.4953054 ,  2.35274482],
[ 1.00459142, -1.05172286],
[ 2.31414829,  2.29519066],
[ 1.43117438, -0.70808284],
[-0.45276343, -0.31703771],
[-0.8839074 , -0.76619479],
[ 0.73254597,  0.69041433],
```

```
       [ 1.23390668,  1.1968407 ],
       [ 1.04578316, -1.09977558],
       [ 0.87717639, -1.15469945],
       [ 0.78779153, -1.24378397],
       [-1.34263211, -1.68056461],
       [ 1.21530116, -0.96090774],
       [-0.60726168, -0.21501135],
       [ 0.7114472 ,  0.8387787 ],
       [-0.80669401, -0.63533093],
       [-0.89791284, -0.79822106],
       [ 0.3808594 , -1.57866861],
       [ 2.33026777,  2.25911758],
       [-1.21336512, -1.41952688],
       [-1.24263195, -1.46332865],
       [ 1.83708868, -0.33281274],
       [ 0.88259274, -1.13663628],
       [-1.22681064, -1.45523831],
       [ 0.37878997, -1.5591055 ],
       [-0.21198653, -0.20665158],
       [ 0.73375167, -1.24567514],
       [ 0.0544508 , -0.01749943],
       [ 3.17435468,  2.97121283],
       [ 0.37705866, -1.47857623],
       [-0.5640052 , -0.13254064],
       [-0.87327398, -0.73188489],
       [-0.85854066, -0.73645459],
       [ 0.80928967,  0.83094292],
       [ 0.64569333,  0.69203257],
       [ 1.8669662 , -0.36915809],
       [-1.39979289, -1.81583166],
       [ 1.68674524, -0.35904111],
       [-1.45691287, -1.92295259],
       [ 1.07746664, -0.9609536 ],
       [-0.18494807,  0.61682301],
       [ 2.27092815,  2.12650838],
       [ 0.7314302 , -1.14361722],
       [-0.89533089, -0.78762996],
       [ 0.01258051,  0.12054434],
       [-1.09897051, -1.20990674],
       [ 0.53358465, -1.52165918],
       [ 1.41276704, -0.67621395]])
```

[43]:
```
y
```

[43]:
```
array([0, 0, 1, 0, 2, 2, 1, 1, 0, 1, 0, 2, 0, 1, 2, 0, 1, 2, 1, 0, 1, 0,
       0, 0, 2, 1, 2, 0, 2, 2, 0, 2, 1, 1, 0, 0, 2, 1, 2, 1, 1, 2, 1, 1,
       1, 1, 1, 2, 2, 2, 0, 2, 1, 0, 1, 0, 1, 2, 1, 1, 0, 0, 0, 2, 0, 2,
```

```
1, 2, 2, 0, 1, 2, 2, 0, 0, 2, 0, 1, 0, 1, 1, 0, 2, 2, 2, 1, 1, 0,
2, 0, 2, 0, 2, 1, 0, 2, 1, 2, 0, 0])
```

3.2 Do the train test split of the data with test size 20%

[44]:
```
from sklearn.model_selection import train_test_split
x_train,x_test,y_train,y_test = train_test_split(x,y,test_size=.
 ↪2,random_state=42)
```

3.3 Next we will create an object of LogisticRegression class as clf. The same class can be used for softmax regression

[45]:
```
from sklearn.linear_model import LogisticRegression

clf = LogisticRegression(multi_class='multinomial')

clf.fit(x_train,y_train)
```

[45]:
```
LogisticRegression(multi_class='multinomial')
```

3.3.1 Now we can fit the model

[46]:
```
y_pred = clf.predict(x_test)
```

3.3.2 Next print the accuracy of your model

[47]:
```
from sklearn.metrics import accuracy_score
print(f"The accuracy of the model is:{accuracy_score(y_test,y_pred)*100} %")
```

```
The accuracy of the model is:90.0 %
```

3.4 Further, we can try to plot the decision boundaries in this case.

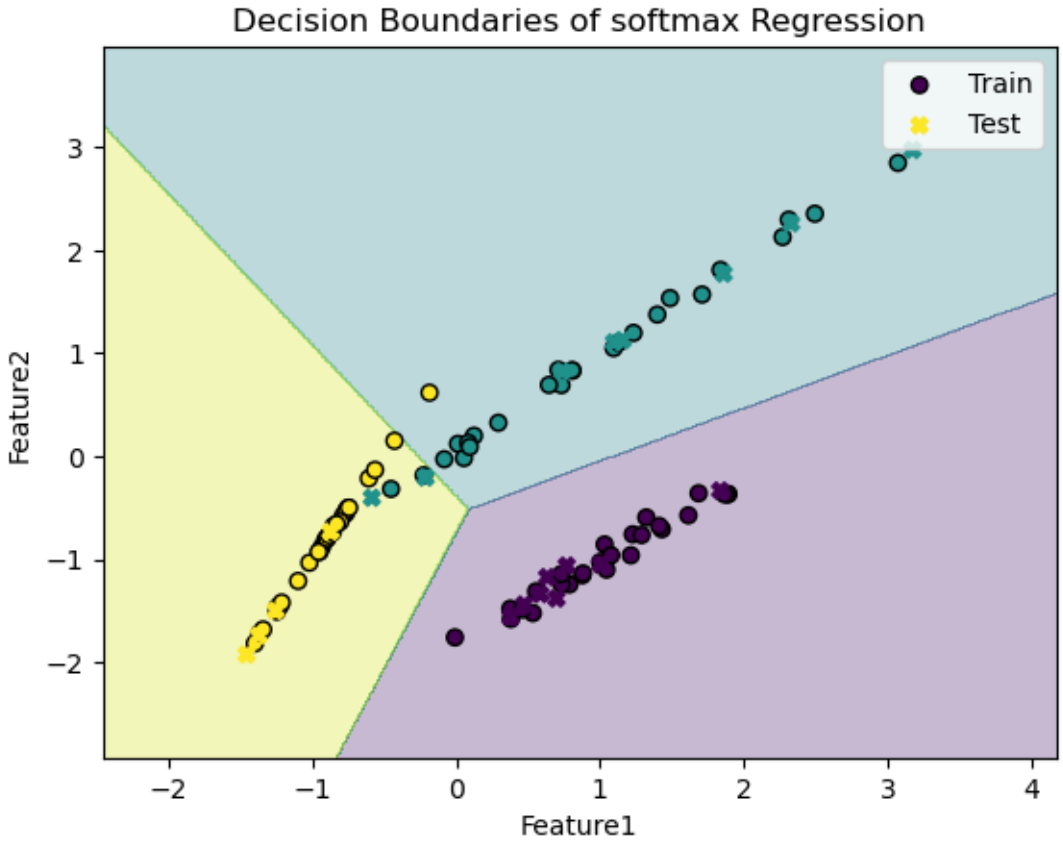
[48]:
```
x_min,x_max = x[:,0].min()-1, x[:,0].max()+1
y_min,y_max = x[:,1].min()-1,x[:,1].max()+1
xx,yy = np.meshgrid(np.linspace(x_min,x_max,500),np.linspace(y_min,y_max,500))
```

[49]:
```
z = clf.predict(np.c_[xx.ravel(),yy.ravel()])

z = z.reshape(xx.shape)

plt.contourf(xx,yy,z,alpha = 0.3)
plt.scatter(x_train[:,0],x_train[:,1],c = y_train,edgecolors='k',label =␣
 ↪'Train')
plt.scatter(x_test[:,0],x_test[:,1],c = y_test,marker='X',label = 'Test')
plt.xlabel("Feature1")
plt.ylabel("Feature2")
```

```
plt.title("Decision Boundaries of softmax Regression")
plt.legend()
plt.show()
```



3.5 Q2. Next try to implement softmax regression to fit a model in connection with the dataset "Croprecommendation.csv" available for you to download in moodle.

3.6 Loading the dataset

[50]:
```
df = pd.read_csv(r"D:\study material\VIT_Data_Science\Winter_Sem\Data Mining␣
↪and Machine Learning Lab\Class_notes\ML_exp5\train_set_label.csv")
```

[51]:
```
df
```

[51]:

	N	P	K	temperature	humidity	ph	\
0	17.000000	136.000000	196.00000	23.871923	90.499390	5.882156	
1	49.000000	69.000000	82.00000	18.315615	15.361435	7.263119	
2	74.000000	49.000000	38.00000	23.314104	71.450905	7.488014	
3	104.000000	35.000000	28.00000	27.510061	50.666872	6.983732	

```
4       23.000000   72.000000   84.00000    19.020613   17.131591   6.920251
…         …           …         …           …           …           …
1645    40.000000   17.000000   15.00000    21.350934   90.949297   7.871063
1646    40.000000   18.000000   43.00000    19.386038   86.790585   5.767373
1647    35.000000  135.000000  199.00000    21.774667   80.549426   6.400720
1648    97.000000   35.000000   26.00000    24.914610   53.741447   6.334610
1649    19.665506   53.221835   21.55633    28.018740   81.158238   6.816712

         rainfall         crop
0      103.054809        apple
1       81.787105     chickpea
2      164.497037         jute
3      143.995555       coffee
4       79.926981     chickpea
…         …           …
1645   107.086209       orange
1646   109.913098  pomegranate
1647    69.396304       grapes
1648   166.254931       coffee
1649    42.427374     mungbean

[1650 rows x 8 columns]
```

Columns Explained

- N (Nitrogen content in soil) – Amount of nitrogen in the soil.
- P(Phosphorus content in soil) – Amount of phosphorus in the soil.
- K (Potassium content in soil) – Amount of potassium in the soil.
- Temperature (°C)- Air temperature at the location.
- Humidity (%)- Percentage of moisture in the air.
- pH - Acidity or alkalinity of the soil.
- Rainfall (mm) -Annual rainfall received.
- Crop (Target variable) - The recommended crop based on the given conditions.

3.7 Data cleaning

3.7.1 Checking for missing values

[52]:
```
df.isna().sum()
```

[52]:
```
N              0
P              0
K              0
temperature    0
humidity       0
ph             0
rainfall       0
crop           0
```

```
dtype: int64
```

- inference : no missing or null values present in the dataset

3.7.2 Checking for duplicate values

[53]:
```
df.duplicated().sum()
```

[53]:
```
0
```

- inference no duplicate values

[54]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1650 entries, 0 to 1649
Data columns (total 8 columns):
 #   Column       Non-Null Count  Dtype  
---  ------       --------------  -----  
 0   N            1650 non-null   float64
 1   P            1650 non-null   float64
 2   K            1650 non-null   float64
 3   temperature  1650 non-null   float64
 4   humidity     1650 non-null   float64
 5   ph           1650 non-null   float64
 6   rainfall     1650 non-null   float64
 7   crop         1650 non-null   object 
dtypes: float64(7), object(1)
memory usage: 103.3+ KB
```

[55]:
```
df.describe()
```

[55]:

	N	P	K	temperature	humidity	ph	rainfall
count	1650.000000	1650.000000	1650.000000	1650.000000	1650.000000	1650.000000	1650.000000
mean	50.370308	53.419241	48.111081	25.647214	71.563115	6.485583	103.965778
std	36.743966	33.320501	50.537044	5.005005	22.198130	0.765865	55.510324
min	0.000000	5.000000	5.000000	9.467960	14.273280	3.525366	20.360011
25%	21.000000	27.000000	20.552276	22.807269	60.120113	5.986160	65.025621
50%	37.000000	52.000000	31.575398	25.656980	80.547206	6.426118	95.246217
75%	84.738202	68.000000	49.000000	28.529953	90.003702		
max	136.000000	145.000000	205.000000	42.936054	99.981876		

```
75%        6.924943    127.887636
max        9.935091    298.560117
```

[56]:
```
df['crop'].value_counts()
```

[56]:
```
crop
apple          75
chickpea       75
muskmelon      75
papaya         75
kidneybeans    75
pigeonpeas     75
maize          75
lentil         75
rice           75
orange         75
blackgram      75
banana         75
mungbean       75
pomegranate    75
mothbeans      75
mango          75
grapes         75
coconut        75
watermelon     75
coffee         75
jute           75
cotton         75
Name: count, dtype: int64
```

3.8 Using label encoder to transform the categorical values of the crop column to numerical values

[57]:
```
from sklearn.preprocessing import LabelEncoder
le = LabelEncoder()
encoded = le.fit_transform(df['crop'])
```

[58]:
```
encoded
```

[58]:
```
array([ 0,  3,  8, …,  7,  5, 14])
```

[59]:
```
x = df.drop('crop',axis =1 )
```

[60]:
```
y = encoded
```

[61]:
```
x_train,x_test,y_train,y_test = train_test_split(x,y,test_size=0.
↪2,random_state=42)
```

```
clf1 = LogisticRegression(multi_class='multinomial')

clf1.fit(x_train,y_train)
```

```
C:\Users\TUFAN\AppData\Roaming\Python\Python312\site-
packages\sklearn\linear_model\_logistic.py:469: 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(
```

[61]:
```
LogisticRegression(multi_class='multinomial')
```

[62]:
```
y_pred1 = clf1.predict(x_test)
print(f"The accuracy of the model is:{accuracy_score(y_test,y_pred1)*100} %")
```

```
The accuracy of the model is:94.54545454545455 %
```