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May 29, 2023

1 Exploratory data analysis of the Cheese datasets

Title : Final project Machine Learning

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[ ]:

```

```

2 Introduction

2.1 Question of interests

In this analysis, I will be analysing the cheese datasets.

I am interested in trying to get the highest precision of the fat level for the cheeses provided

• canadian_cheese.csv – This file contains information on cheese only from canada • cheese.csv – This file includes information on cheese that we are more interested in :- moisture % and fat level

Let us start by importing methods and the tables to do some basic visualizations

[7]:

```
import pandas as pd
import altair as alt

import sklearn
from sklearn.model_selection import train_test_split, cross_validate
from sklearn.tree import DecisionTreeClassifier
from sklearn.dummy import DummyClassifier
from sklearn.tree import DecisionTreeClassifier

from sklearn.pipeline import Pipeline, make_pipeline
from sklearn.compose import make_column_transformer
from sklearn.impute import SimpleImputer

from sklearn.preprocessing import (FunctionTransformer, Normalizer,␣
↪OneHotEncoder, StandardScaler, normalize, scale)
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.neighbors import KNeighborsClassifier
from sklearn.svm import SVC, SVR
from sklearn.linear_model import LogisticRegression
```

```
from sklearn.metrics import accuracy_score, precision_score, recall_score,␣
↪f1_score
from sklearn.model_selection import RandomizedSearchCV

from sklearn import metrics
from sklearn.metrics import plot_confusion_matrix, classification_report
```

[11]:
```
# import all the required files

#canada_cheese_url = 'https://github.com/UBC-MDS/intro-ml-students/blob/main/
↪release/final_project/data/canadianCheeseDirectory.csv'
canadian_cheese_df = pd.read_csv("intro-ml-students/release/final_project/data/
↪canadianCheeseDirectory.csv")
#pd.read_csv(canada_cheese_url)

#cheese_url='https://github.com/UBC-MDS/intro-ml-students/blob/main/release/
↪final_project/data/cheese_data.csv'
cheese_df = pd.read_csv("intro-ml-students/release/final_project/data/
↪cheese_data.csv")
#pd.read_csv(cheese_url)
```

[12]:
```
canadian_cheese_df.head()
```

[12]:
```
   CheeseId                         CheeseNameEn  \
0       228                                  NaN
1       242                                  NaN
2       301  Provolone Sette Fette (Tre-Stelle)
3       303                                  NaN
4       319                                  NaN

                         CheeseNameFr       ManufacturerNameEn  \
0             Sieur de Duplessis (Le)                      NaN
1                 Tomme Le Champ Doré                      NaN
2  Provolone Sette Fette (Tre-Stelle)  Tre Stelle (Arla Foods)
3                       Geai Bleu (Le)                      NaN
4                           Gamin (Le)                      NaN

        ManufacturerNameFr ManufacturerProvCode ManufacturingTypeEn  \
0  Fromages la faim de loup                   NB           Farmstead
1  Fromages la faim de loup                   NB           Farmstead
2                       NaN                   ON          Industrial
3  Fromages la faim de loup                   NB           Farmstead
4  Fromages la faim de loup                   NB           Farmstead

  ManufacturingTypeFr                          WebSiteEn  \
0           Fermière                                NaN
1           Fermière                                NaN
```

```
2       Industrielle  http://www.trestelle.ca/english/
3           Fermière                              NaN
4           Fermière                              NaN

                        WebSiteFr  …  Organic    CategoryTypeEn  \
0                             NaN  …        0       Firm Cheese
1                             NaN  …        0  Semi-soft Cheese
2  http://www.trestelle.ca/francais/  …        0       Firm Cheese
3                             NaN  …        0    Veined Cheeses
4                             NaN  …        1  Semi-soft Cheese

    CategoryTypeFr MilkTypeEn MilkTypeFr MilkTreatmentTypeEn  \
0       Pâte ferme        Ewe     Brebis            Raw Milk
1  Pâte demi-ferme        Cow      Vache            Raw Milk
2       Pâte ferme        Cow      Vache         Pasteurized
3   Pâte persillée        Cow      Vache            Raw Milk
4  Pâte demi-ferme        Cow      Vache            Raw Milk

  MilkTreatmentTypeFr   RindTypeEn    RindTypeFr LastUpdateDate
0            Lait cru  Washed Rind  Croûte lavée     2016-02-03
1            Lait cru  Washed Rind  Croûte lavée     2016-02-03
2          Pasteurisé          NaN           NaN     2016-02-03
3            Lait cru          NaN           NaN     2016-02-03
4            Lait cru  Washed Rind  Croûte lavée     2016-02-03

[5 rows x 30 columns]
```

[13]:

```
cheese_df.head()
```

[13]:

```
   CheeseId ManufacturerProvCode ManufacturingTypeEn  MoisturePercent  \
0       228                   NB           Farmstead             47.0
1       242                   NB           Farmstead             47.9
2       301                   ON          Industrial             54.0
3       303                   NB           Farmstead             47.0
4       319                   NB           Farmstead             49.4

                                        FlavourEn  \
0                                  Sharp, lactic
1              Sharp, lactic, lightly caramelized
2                         Mild, tangy, and fruity
3  Sharp with fruity notes and a hint of wild honey
4                                    Softer taste

                                  CharacteristicsEn  Organic  \
0                                          Uncooked        0
1                                          Uncooked        0
2  Pressed and cooked cheese, pasta filata, inter…        0
```

```
3                                                   NaN         0
4                                                   NaN         1

     CategoryTypeEn MilkTypeEn MilkTreatmentTypeEn   RindTypeEn  \
0       Firm Cheese        Ewe            Raw Milk  Washed Rind
1  Semi-soft Cheese        Cow            Raw Milk  Washed Rind
2       Firm Cheese        Cow         Pasteurized          NaN
3    Veined Cheeses        Cow            Raw Milk          NaN
4  Semi-soft Cheese        Cow            Raw Milk  Washed Rind

                         CheeseName   FatLevel
0             Sieur de Duplessis (Le)  lower fat
1                 Tomme Le Champ Doré  lower fat
2  Provolone Sette Fette (Tre-Stelle)  lower fat
3                      Geai Bleu (Le)  lower fat
4                          Gamin (Le)  lower fat
```

There are some features here that we will be dropping as they wont be helping us with our prediction; - CheeseId, - ManufacturerProvCode, - ManufacturingTypeEn, - CharacteristicsEn, - RindTypeEn, - CheeseName

[15]:
```
cheese_train_df=train_df = cheese_df.
↪drop(columns=['CheeseId','ManufacturerProvCode',␣
↪'ManufacturingTypeEn','CharacteristicsEn', 'RindTypeEn', 'CheeseName'])

cheese_train_df
```

[15]:
```
      MoisturePercent                                         FlavourEn  \
0                47.0                                     Sharp, lactic
1                47.9                  Sharp, lactic, lightly caramelized
2                54.0                               Mild, tangy, and fruity
3                47.0   Sharp with fruity notes and a hint of wild honey
4                49.4                                      Softer taste
…                 …                                                 …
1037             37.0  Dill, Caraway, Chili Pepper, Cumin, Sage, Chiv…
1038             46.0                               Mild and Deep Flavor
1039             40.0  Grassy tang and restrained saltiness that refl…
1040             34.0  Sweet and tangy flavours combine with hoppy no…
1041             31.5  Available in different flavor: original, herb …

      Organic    CategoryTypeEn MilkTypeEn MilkTreatmentTypeEn    FatLevel
0           0       Firm Cheese        Ewe            Raw Milk   lower fat
1           0  Semi-soft Cheese        Cow            Raw Milk   lower fat
2           0       Firm Cheese        Cow         Pasteurized   lower fat
3           0    Veined Cheeses        Cow            Raw Milk   lower fat
4           1  Semi-soft Cheese        Cow            Raw Milk   lower fat
…         …                 …        …                   …           …
```

```
1037         1       Hard Cheese        Cow         Pasteurized  higher fat
1038         0      Fresh Cheese        Cow         Pasteurized   lower fat
1039         0    Veined Cheeses        Ewe           Thermised  higher fat
1040         0  Semi-soft Cheese        Ewe           Thermised  higher fat
1041         0      Fresh Cheese        Cow         Pasteurized  higher fat

[1042 rows x 7 columns]
```

Now we can import the data and split it to train and test data frames.

The dataframe will be split into train and test data and into a ratio 8:2 for the respective data and named `X_train`, `y_train`, `X_test` and `y_test` using a random_state of 123.

[16]:
```
train_df, test_df = train_test_split(cheese_train_df, test_size=0.2,␣
↪random_state=123)
```

Now we are going to use info() to check if there are null values.. We will also see the percentage of lower fat and higher fat in the dataset provided

[17]:
```
train_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 833 entries, 482 to 1041
Data columns (total 7 columns):
 #   Column                Non-Null Count  Dtype
---  ------                --------------  -----
 0   MoisturePercent       821 non-null    float64
 1   FlavourEn             637 non-null    object
 2   Organic               833 non-null    int64
 3   CategoryTypeEn        813 non-null    object
 4   MilkTypeEn            832 non-null    object
 5   MilkTreatmentTypeEn  781 non-null    object
 6   FatLevel              833 non-null    object
dtypes: float64(1), int64(1), object(5)
memory usage: 52.1+ KB
```

from this data it looks like MoisturePercent and Organic column will help with our prediction as our feature for our target- Fatlevel as they have the least non-null entries and we arent really interested in milk type

But before that there are null values in our dataframe and we will try to “fix” it later after we find which feature will help us best

[19]:
```
Moisture_to_fat = alt.Chart(train_df).mark_bar().encode(
    alt.X('FatLevel:N', title="Fat Level"),
    alt.Y('MoisturePercent:Q', title="Moisture Percent")
).properties(title='Percentage of Moisture to Fat level')
Moisture_to_fat
```

[19]: alt.Chart(…)

According to this bar graph, higher fat level has a lower moisture percentage.

Now lets look at if Organic has any correlation:

[25]:
```
Organic_to_fat= alt.Chart(train_df).mark_bar().encode(
    alt.X('FatLevel:N', title="Fat Level"),
    alt.Y("Organic:N", title="Organic or not")
).properties(width= 300,height = 300, title="Organic to Fat level")
Organic_to_fat
```

[25]: alt.Chart(…)

Now we can compare these two features using the plotted graph and it seems that the Moisture percentage will be the most helpful to help us with our prediction I am going to use the column `FatLevel` column as my target y and everything else that is left as feature X

[40]:
```
X_train, y_train = train_df.drop(columns=['FatLevel']), train_df['FatLevel']
X_test, y_test = test_df.drop(columns=['FatLevel']), test_df['FatLevel']
```

[72]:
```
train_df['FatLevel'].replace(['lower fat','higher fat'],[0,1],inplace=True)
test_df['FatLevel'].replace(['lower fat','higher fat'],[0,1],inplace=True)

train_df
```

```
/opt/conda/lib/python3.8/site-packages/pandas/core/series.py:4509:
SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-
docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  return super().replace(
```

[72]:
```
      MoisturePercent                                          FlavourEn  \
482              48.0                                 Sharp, hazelnutty
896              45.0                                               NaN
421              50.0                                              Mild
929              40.0                                               NaN
737              65.0                                        Acidulous
…                 …                                                 …
638              44.0                                              Mild
113              52.0                                               NaN
96               74.0                          Milky, smooth and creamy
106              40.0                                     Sharp flavour
1041             31.5  Available in different flavor: original, herb …

      Organic    CategoryTypeEn MilkTypeEn MilkTreatmentTypeEn  FatLevel
```

```
482         0  Semi-soft Cheese        Cow        Pasteurized        0
896         0    Veined Cheeses        Cow        Pasteurized        1
421         0       Soft Cheese        Cow        Pasteurized        0
929         0  Semi-soft Cheese        Cow        Pasteurized        1
737         0      Fresh Cheese        Cow        Pasteurized        0
…       …               …        …                …       …
638         0       Soft Cheese        Cow           Raw Milk        0
113         0       Soft Cheese        Cow        Pasteurized        0
96          0      Fresh Cheese        Cow        Pasteurized        0
106         0  Semi-soft Cheese        Cow        Pasteurized        1
1041        0      Fresh Cheese        Cow        Pasteurized        1

[833 rows x 7 columns]
```

Let's make a baseline model using DummyClassifier. Build a DummyClassifier named dummy using strategy='most_frequent'. Perform crossvalidation on the training portion and return the training score

[74]:
```
dummy = DummyClassifier(strategy='most_frequent')
dummy_score = pd.DataFrame(cross_validate(
    dummy, X_train, y_train, return_train_score=True))
print(dummy_score.mean())
```

```
fit_time       0.001137
score_time     0.000366
test_score     0.657860
train_score    0.657863
dtype: float64
```

Next is defining the different types of features present in the data that will be used in the modeling process. The feature types are:

- numeric_features: These are the numerical features in the data, such as MoisturePercent and Organic.
- categorical_features: These are the categorical features in the data, such as CategoryTypeEn, MilkTypeEn, and MilkTreatmentTypeEn.
- binary_features: These are the features that have only two possible values, such as Organic. It's worth noting that Organic is already included in numeric_features, but this is not an issue since it is a binary feature.
- text_features: These are the features that contain text data, such as FlavourEn.

[75]:
```
numeric_features = ['MoisturePercent' , 'Organic']
categorical_features = ['CategoryTypeEn' , 'MilkTypeEn' , 'MilkTreatmentTypeEn']
binary_features = ['Organic']
text_features = ['FlavourEn']
```

```
[76]: numeric_transformer = make_pipeline(SimpleImputer(strategy = 'median'),
                                    StandardScaler())
categorical_transformer = make_pipeline(SimpleImputer(strategy =␣
 ↪'most_frequent', fill_value = 'missing'),
                                    OneHotEncoder(handle_unknown = 'ignore'))

binary_transformer = make_pipeline(SimpleImputer(strategy = 'most_frequent',␣
 ↪fill_value = 'missing'),
                                    OneHotEncoder( drop = 'if_binary'))
text_transformer = make_pipeline( SimpleImputer(strategy = 'most_frequent',␣
 ↪fill_value = 'missing'),
                                    CountVectorizer())
```

```
[ ]:
```

```
[61]: preprocessor = make_column_transformer(
    (numeric_transformer,numeric_features),
    (categorical_transformer, categorical_features),
    (binary_transformer, binary_features))
```

Next we calculate f1, precision, and recall to compare the accuracy for each scoring metric

I am going to test the performance of four different models on a dataset

```
[83]: scoring = ['f1', 'precision','recall','accuracy']

score_dict = {}
models = {
    "Logistic Regression":  LogisticRegression(class_weight='balanced'),
    "Decision tree": DecisionTreeClassifier(class_weight='balanced'),
    "RBF SVM": SVC(class_weight='balanced'),
    "kNN": KNeighborsClassifier(weights='distance')
}

for model in models.items():
    pipe = Pipeline(steps=[("preprocessor", preprocessor),
                           (model)])

    scores = pd.DataFrame(cross_validate(
        pipe, X_train,  y_train, scoring=scoring, return_train_score=True,␣
 ↪cv=10))

    score_dict[model] = {'mean_train_f1': scores['train_f1'].mean().round(4),
                         'mean_test_f1': scores['test_f1'].mean().round(4),
                         'mean_train_precision': scores['train_precision'].
 ↪mean().round(4),
```

```
                              'mean_test_precision': scores['test_precision'].
↪mean().round(4),
                              'mean_train_recall': scores['train_recall'].mean().
↪round(4),
                              'mean_test_recall': scores['test_recall'].mean().
↪round(4),
                              'mean_train_accuracy': scores["train_accuracy"].
↪mean().round(4),
                              'mean_test_accuracy': scores["test_accuracy"].mean().
↪round(4)}
score_df = pd.DataFrame(score_dict).T
score_df
```

[83]:
```
mean_train_f1  \
Logistic Regression LogisticRegression(class_weight='balanced')
0.6860
Decision tree       DecisionTreeClassifier(class_weight='balanced')
0.8673
RBF SVM             SVC(class_weight='balanced')
0.7363
kNN                 KNeighborsClassifier(weights='distance')
0.8560

mean_test_f1  \
Logistic Regression LogisticRegression(class_weight='balanced')
0.6774
Decision tree       DecisionTreeClassifier(class_weight='balanced')
0.7379
RBF SVM             SVC(class_weight='balanced')
0.6946
kNN                 KNeighborsClassifier(weights='distance')
0.7325

mean_train_precision  \
Logistic Regression LogisticRegression(class_weight='balanced')
0.6178
Decision tree       DecisionTreeClassifier(class_weight='balanced')
0.8178
RBF SVM             SVC(class_weight='balanced')
0.6404
kNN                 KNeighborsClassifier(weights='distance')
0.8752

mean_test_precision  \
Logistic Regression LogisticRegression(class_weight='balanced')
0.6125
Decision tree       DecisionTreeClassifier(class_weight='balanced')
```

```
0.7035
RBF SVM             SVC(class_weight='balanced')
0.6035
kNN                 KNeighborsClassifier(weights='distance')
0.7519

mean_train_recall  \
Logistic Regression LogisticRegression(class_weight='balanced')
0.7711
Decision tree       DecisionTreeClassifier(class_weight='balanced')
0.9236
RBF SVM             SVC(class_weight='balanced')
0.8666
kNN                 KNeighborsClassifier(weights='distance')
0.8402

mean_test_recall  \
Logistic Regression LogisticRegression(class_weight='balanced')
0.7608
Decision tree       DecisionTreeClassifier(class_weight='balanced')
0.7829
RBF SVM             SVC(class_weight='balanced')
0.8213
kNN                 KNeighborsClassifier(weights='distance')
0.7188

mean_train_accuracy  \
Logistic Regression LogisticRegression(class_weight='balanced')
0.7584
Decision tree       DecisionTreeClassifier(class_weight='balanced')
0.9033
RBF SVM             SVC(class_weight='balanced')
0.7878
kNN                 KNeighborsClassifier(weights='distance')
0.9034

mean_test_accuracy
Logistic Regression LogisticRegression(class_weight='balanced')
0.7514
Decision tree       DecisionTreeClassifier(class_weight='balanced')
0.8104
RBF SVM             SVC(class_weight='balanced')
0.7526
kNN                 KNeighborsClassifier(weights='distance')
0.8199
```

We can see that Fatlevel is an imbalanced distribution and it looks like the KNN model has the highest accuracy and precision amongst the scoring metrics so we will be using it to hypertune.I I am RandomizedSearchCV will be used since we have a smaller dataset now.

[84]:
```
pipe = Pipeline(steps=[('preprocessor', preprocessor),
                 ('kNN', KNeighborsClassifier(weights='distance'))])
param_grid = {
    "kNN__n_neighbors": range(1, 10),
    "kNN__algorithm": ['auto', 'brute']
}

random_search = RandomizedSearchCV(pipe, param_grid, cv=10, verbose=1,␣
 ↪n_jobs=-1,
                                   n_iter=10, random_state=123,␣
 ↪return_train_score=True, scoring='accuracy')
random_search.fit(X_train, y_train)
best_params = random_search.best_params_
best_model = random_search.best_estimator_
best_score = random_search.best_score_
print(best_params)
print(best_score)
```

```
Fitting 10 folds for each of 10 candidates, totalling 100 fits
{'kNN__n_neighbors': 7, 'kNN__algorithm': 'brute'}
0.8235513482501435
```

With a total of 100 fits using 10 folds we are able to obtain the best model,number of n_neighbors and precision score

With the optimized settings we can go ahead and score the test data

[67]:
```
pred_y = best_model.predict(X_test)
precision_score(y_test, pred_y)
```

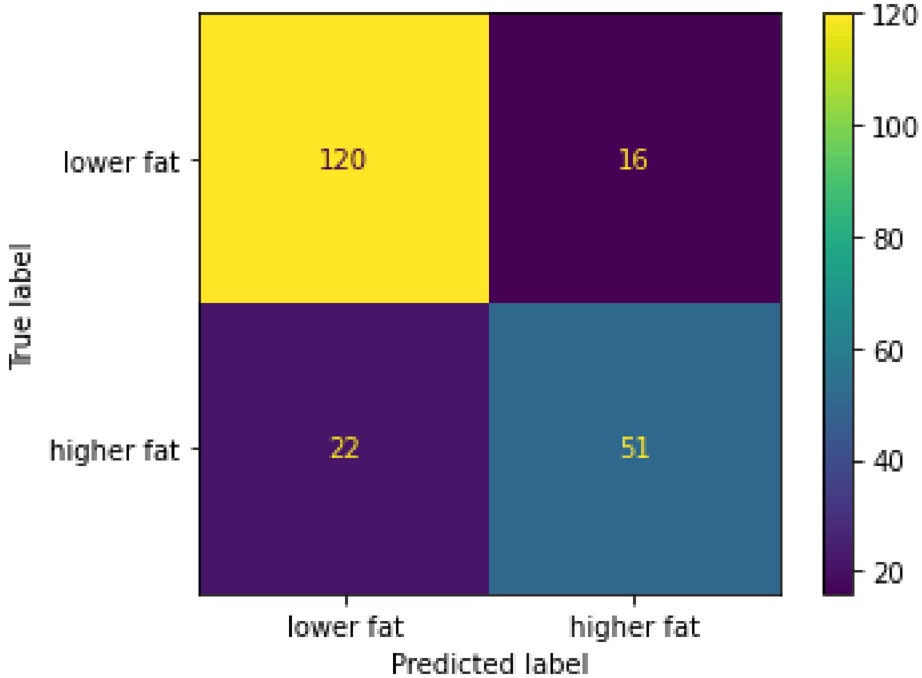
[67]:
```
0.7611940298507462
```

Now im gonna plot the confusion matrix along with the classification report

[70]:
```
best_model.fit(X_train, y_train)

plot_confusion_matrix(best_model, X_test, y_test, display_labels=['lower fat',␣
 ↪'higher fat'])
```

[70]:
```
<sklearn.metrics._plot.confusion_matrix.ConfusionMatrixDisplay at
0x7f828a664e20>
```



[71]:
```
print(classification_report(y_test, pred_y,
      target_names=['lower fat', 'higher fat']))
```

```
              precision    recall  f1-score   support

   lower fat       0.85      0.88      0.86       136
  higher fat       0.76      0.70      0.73        73

    accuracy                           0.82       209
   macro avg       0.80      0.79      0.80       209
weighted avg       0.82      0.82      0.82       209
```

3 Discussion

In this work, I analyzed the Cheese dataset and tried to compute which feature can produce the best score to predict the target FatLevel. Before answering this question, I did some exploratory data analysis to see which feature would correlate with the target best.

The KNNClassifier has the highest accuracy and precision.

The test precision score for this model came down to 0.8235513482501435 with 'n_neighbors' set to 7 and 'algorithm' to 'brute' as the optimized settings

4 References:

4.0.1 Introduction to Machine Learning, UBC

4.0.2 Cheese data - https://github.com/UBC-MDS/intro-ml-students/tree/main/release/final_project/data