Part3_Model

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1 File Information

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Course: DSC680 - Applied Data Science

Project: College Recommendation Engine

Purpose: Build model(s)

Usage: Python 3.7.6

Developed using Jupter Notebook 6.0.3

2 Data Source

College Scorecard is managed by the US Department of Education and provides results such as costs and graduation rates.
College Scorecard. (n.d.). Retrieved March 15, 2021, from https://collegescorecard.ed.gov/

3 References

Albon, C. (2018). Machine learning with Python cookbook: practical solutions from preprocessing to deep learning. O'Reilly.

https://towardsdatascience.com/build-your-own-clustering-based-recommendation-engine-in-15-minutes-bdddd591d394

4 Part 3

In Part 3, I will build a k-Means clustering model to perform unsupervised learning to group similar colleges.

4.1 Import required packages

[1]:

```
# Suppress Warnings
#import warnings
#warnings.filterwarnings('ignore')

import pandas as pd
```

```python
import numpy as np
from sklearn.preprocessing import StandardScaler
from sklearn.cluster import KMeans
import matplotlib.pyplot as plt
import pickle
```

5 Prepare Data

[2]:

```python
# Load data into dataframe
data_file = "Data\Scorecard\Cleaned_Scorecard.csv"
df = pd.read_csv(data_file)
```

5.1 Eliminate non-numeric features

[3]:

```python
print(df.dtypes)
```

```
Unnamed: 0                     int64
UNITID                         int64
SAT_AVG                        int64
ACT_MEDIAN                     int64
TUITION_OUT_ST                 int64
LOCALE                         int64
LATITUDE                     float64
LONGITUDE                    float64
ADM_RATE_ALL                 float64
SIZE                           int64
ONLINE_ONLY                    int64
Y4_COMPLETION_RT             float64
PT_RETENTION_RT              float64
UG_INCOMP_1Y_REPAY_RT        float64
UG_GRAD_4Y_REPAY_RT          float64
UG_PLUS_1Y_REPAY_RT          float64
Y4_COMPLETION_RT_POOLED      float64
FED_LN_AWD_RT                float64
Y5_UG_REPAY_RT               float64
Y5_PLUS_LN_REPAY_RT          float64
DBRR10_FED_UG_RT             float64
DBRR10_PP_UG_RT              float64
OPEID                          int64
OPEID6                         int64
SCHOOL_NAME                   object
CITY                          object
STABBR                        object
ZIP                           object
MAIN_CAMPUS                    int64
NUM_BRANCH                     int64
OWNERSHIP                      int64
```

```
ST_FIPS                          int64
REGION                           int64
NPT41_PRIV                     float64
PVT_INCOME_30_40K              float64
TUITION_IN_ST                    int64
INSTR_EXP_PER_FTE                int64
Y3_LN_DEFAULT_RT               float64
MEDIAN_DEBT                    float64
MEDIAN_PLUS_LN_DEBT              int64
MEDIAN_PLUS_LN_DEBT_GRADS      float64
Y2_LN_DEFAULT_RT               float64
Y2_LN_DELINQ_RT                float64
FED_UG_PAIDINFULL              float64
UG_GRAD_2Y_FORBEAR_RT          float64
LPSTAFFORD_CNT                 float64
NUM_STU_PLUS_LN_BAL              int64
LPPPLUS_AMT                    float64
FED_SCHOOL_CD                   object
dtype: object
```

[4]:

```
# Keep only numeric fields
train_df = df.select_dtypes(include=[np.number])

train_df.head()
```

[4]:

```
   Unnamed: 0  UNITID  SAT_AVG  ACT_MEDIAN  TUITION_OUT_ST  LOCALE   LATITUDE  \
0           1  100654      957          18           18354      12  34.783368
1           2  100663     1220          25           19704      12  33.505697
2           3  100690        0           0            6900      12  32.362609
3           4  100706     1314          28           22362      12  34.724557
4           5  100724      972          18           19396      12  32.364317

   LONGITUDE  ADM_RATE_ALL   SIZE  …  MEDIAN_DEBT  MEDIAN_PLUS_LN_DEBT  \
0 -86.568502        0.8986   4990  …       3606.0                14838
1 -86.799345        0.9211  13186  …       7504.0                16145
2 -86.174010        1.0000    351  …        514.0                    0
3 -86.640449        0.8087   7458  …       3021.0                13524
4 -86.295677        0.9774   3903  …       3609.0                15351

   MEDIAN_PLUS_LN_DEBT_GRADS  Y2_LN_DEFAULT_RT  Y2_LN_DELINQ_RT  \
0                    16106.0          0.172640         0.074776
1                    16954.0          0.060389         0.034483
2                        NaN          0.157191         0.050167
3                    16550.0          0.055035         0.031390
4                    18952.0          0.173804         0.061713

   FED_UG_PAIDINFULL  UG_GRAD_2Y_FORBEAR_RT  LPSTAFFORD_CNT  \
0           0.007926                 0.266409         31374.0
1           0.059675                 0.156121         56997.0
2                NaN                 0.000000          4463.0
3           0.092947                 0.100349         19702.0
4           0.007872                 0.286976         34246.0

   NUM_STU_PLUS_LN_BAL  LPPPLUS_AMT
0                 5201  113949554.0
1                 3727   87421879.0
2                   16     309618.0
3                 1397   29789762.0
4                 4602   95359062.0

[5 rows x 44 columns]
```

[5]:

```python
# Find null records
count_nan_in_df = train_df.isnull().sum()
print (count_nan_in_df)
```

```
Unnamed: 0                      0
UNITID                          0
SAT_AVG                         0
ACT_MEDIAN                      0
TUITION_OUT_ST                  0
LOCALE                          0
LATITUDE                        0
LONGITUDE                       0
ADM_RATE_ALL                    0
SIZE                            0
ONLINE_ONLY                     0
Y4_COMPLETION_RT                0
PT_RETENTION_RT                 0
UG_INCOMP_1Y_REPAY_RT           0
UG_GRAD_4Y_REPAY_RT             0
UG_PLUS_1Y_REPAY_RT             0
Y4_COMPLETION_RT_POOLED         0
FED_LN_AWD_RT                   0
Y5_UG_REPAY_RT                  0
Y5_PLUS_LN_REPAY_RT             0
DBRR10_FED_UG_RT              207
DBRR10_PP_UG_RT               362
OPEID                           0
OPEID6                          0
MAIN_CAMPUS                     0
NUM_BRANCH                      0
OWNERSHIP                       0
ST_FIPS                         0
REGION                          0
```

```
NPT41_PRIV                  226
PVT_INCOME_30_40K           758
TUITION_IN_ST                 0
INSTR_EXP_PER_FTE             0
Y3_LN_DEFAULT_RT              0
MEDIAN_DEBT                 129
MEDIAN_PLUS_LN_DEBT           0
MEDIAN_PLUS_LN_DEBT_GRADS   407
Y2_LN_DEFAULT_RT              0
Y2_LN_DELINQ_RT               0
FED_UG_PAIDINFULL           427
UG_GRAD_2Y_FORBEAR_RT         0
LPSTAFFORD_CNT               89
NUM_STU_PLUS_LN_BAL           0
LPPPLUS_AMT                 211
dtype: int64
```

[6]:

```
# Handle null Values

# Set null rate data to 0
train_df["DBRR10_FED_UG_RT"].fillna(0, inplace = True)
train_df["DBRR10_PP_UG_RT"].fillna(0, inplace = True)

# Set null monetary data to 0
train_df["FED_UG_PAIDINFULL"].fillna(0, inplace = True)
train_df["LPPPLUS_AMT"].fillna(0, inplace = True)
train_df["PVT_INCOME_30_40K"].fillna(0, inplace = True)

# Impute null median data to median of values in other records
train_df['MEDIAN_DEBT'].fillna(train_df['MEDIAN_DEBT'].median(), inplace=True)
train_df['MEDIAN_PLUS_LN_DEBT_GRADS'].
 ↪fillna(train_df['MEDIAN_PLUS_LN_DEBT_GRADS'].median(), inplace=True)

# Some schools have no students with reported income < $30
# Set cost to 0 from NA
train_df["NPT41_PRIV"].fillna(0, inplace = True)
train_df["LPSTAFFORD_CNT"].fillna(0, inplace = True)
```

```
C:\Users\amomu\Anaconda3\lib\site-packages\pandas\core\series.py:4469:
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
  downcast=downcast,
```

[7]:

```
# Check null records
count_nan_in_df = train_df.isnull().sum()
```

```python
print (count_nan_in_df)
```

```
Unnamed: 0                   0
UNITID                       0
SAT_AVG                      0
ACT_MEDIAN                   0
TUITION_OUT_ST               0
LOCALE                       0
LATITUDE                     0
LONGITUDE                    0
ADM_RATE_ALL                 0
SIZE                         0
ONLINE_ONLY                  0
Y4_COMPLETION_RT             0
PT_RETENTION_RT              0
UG_INCOMP_1Y_REPAY_RT        0
UG_GRAD_4Y_REPAY_RT          0
UG_PLUS_1Y_REPAY_RT          0
Y4_COMPLETION_RT_POOLED      0
FED_LN_AWD_RT                0
Y5_UG_REPAY_RT               0
Y5_PLUS_LN_REPAY_RT          0
DBRR10_FED_UG_RT             0
DBRR10_PP_UG_RT              0
OPEID                        0
OPEID6                       0
MAIN_CAMPUS                  0
NUM_BRANCH                   0
OWNERSHIP                    0
ST_FIPS                      0
REGION                       0
NPT41_PRIV                   0
PVT_INCOME_30_40K            0
TUITION_IN_ST                0
INSTR_EXP_PER_FTE            0
Y3_LN_DEFAULT_RT             0
MEDIAN_DEBT                  0
MEDIAN_PLUS_LN_DEBT          0
MEDIAN_PLUS_LN_DEBT_GRADS    0
Y2_LN_DEFAULT_RT             0
Y2_LN_DELINQ_RT              0
FED_UG_PAIDINFULL            0
UG_GRAD_2Y_FORBEAR_RT        0
LPSTAFFORD_CNT               0
NUM_STU_PLUS_LN_BAL          0
LPPPLUS_AMT                  0
dtype: int64
```

5.2 Standardization

[8]:

```
# Standardize features into array
scaler = StandardScaler()
features_std = scaler.fit_transform(train_df)

features_std
```

[8]:

```
array([[-1.73120939, -1.1602827 ,  0.45343115, …, -0.08513354,
         0.70559181,  0.30577287],
       [-1.72952616, -1.16019784,  0.91757109, …,  0.08830825,
         0.35705198,  0.13645898],
       [-1.72784292, -1.15994327, -1.23547352, …, -0.26729379,
        -0.5204455 , -0.41953831],
       …,
       [ 1.72784292,  2.53671497, -1.23547352, …,  0.37345189,
         0.03097572, -0.06963586],
       [ 1.72952616,  2.53711097, -1.23547352, …, -0.19134574,
        -0.35705267, -0.29983386],
       [ 1.73120939,  2.53862898, -1.23547352, …, -0.11424696,
        -0.27121824, -0.27673791]])
```

6 Model Creation and Evaluation

6.1 Build Model

[9]:

```
# Use Elbow Method to determine best value for k

# Calculates Within-Cluster-Sum of Squared Errors for k from 1 to kmax
def calculate_WSS(points, kmax):

  # Initiate list
  sse = []

  for k in range(1, kmax+1):
    kmeans = KMeans(n_clusters = k).fit(points)
    centroids = kmeans.cluster_centers_
    pred_clusters = kmeans.predict(points)
    curr_sse = 0

    # Calculate square of Euclidean distance of each point from its cluster␣
 ↪center and add to current WSS
    for i in range(len(points)):
      curr_center = centroids[pred_clusters[i]]
      curr_sse += (points[i, 0] - curr_center[0]) ** 2 + (points[i, 1] -␣
 ↪curr_center[1]) ** 2
```

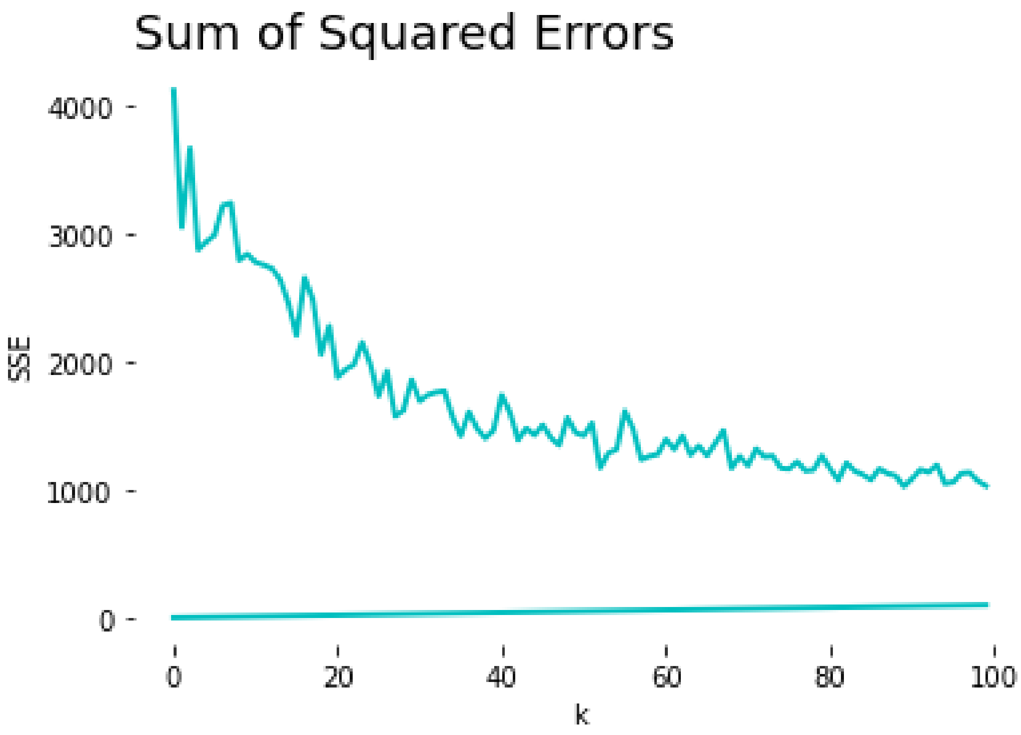
```python
        # Return pairs of k and WWS so they can be plotted
        sse_tup = (k,curr_sse)
        sse.append(sse_tup)

    return sse

# Test output
calculate_WSS(features_std, 10)
```

[9]:

```
[(1, 4115.999999999996),
 (2, 3059.4212503151994),
 (3, 3644.599246722471),
 (4, 2845.5805426818197),
 (5, 2935.4186427435056),
 (6, 3043.9849555606074),
 (7, 2882.408960006184),
 (8, 2849.207259898587),
 (9, 2784.8486009196317),
 (10, 2766.7883661519377)]
```

[31]:

```python
# Plot Elbow Curve (WSS vs. k)
#fig, ax = plt.subplots()  # Create a figure containing a single axes.
# Setup figure w/o axes lines
plt.figure()
plt.axes(frameon=False)

# Plot data
plt.plot(calculate_WSS(features_std, 100), color='c', linewidth=2.0)



# Set plot parameters
plt.title('Sum of Squared Errors', loc='left', fontsize=18)
plt.xlabel('k')
plt.ylabel('SSE')

# Save plot to file
plt.savefig('Elbow_Curve.png', bbox_inches='tight')

# Show Plot
plt.show()
```



[11]:
```
# Create k-Means model
# Selecting k=30 based on the
cluster = KMeans(n_clusters=30, random_state=0, n_jobs=-1)
```

[12]:
```
# Train model
kmeans = cluster.fit(features_std)
```

```
C:\Users\amomu\Anaconda3\lib\site-packages\sklearn\cluster\_kmeans.py:793:
FutureWarning: 'n_jobs' was deprecated in version 0.23 and will be removed in
1.0 (renaming of 0.25).
  " removed in 1.0 (renaming of 0.25).", FutureWarning)
```

[13]:
```
# Save machine learning model
filename = 'kmeans_model.sav'
pickle.dump(kmeans, open(filename, 'wb'))
```

6.1.1 Model Evaluation

[14]:
```
# Vew centroid values
print(kmeans.cluster_centers_)
```

```
[[ 1.51593222  2.2711597  -1.23547352 …  9.37611862  1.51617153
   0.32900296]
 [-0.87711334 -0.64054999  0.51630695 … -0.23810965 -0.34628419
 -0.30935792]
[ 0.52452695 -0.02651169  0.52852398 … -0.239954   -0.30940496
 -0.27394961]
…
[ 1.26425136  1.25232638 -1.23547352 … -0.28551027 -0.52422883
 -0.42151446]
[-0.2491191  -0.08656262 -1.23547352 … -0.26012566 -0.48678957
 -0.39182638]
[-0.45663128 -0.47645366 -1.17628204 … -0.18575183 -0.39311939
 -0.3611353 ]]
```

[15]:

```
# View cluster label
kmeans.labels_
```

[15]:

```
array([21,  5, 10, …, 19, 14, 21])
```

7 Model Deployment

[16]:

```
# Function gets the cluster of a school
def cluster_predict(unit_id):

    # Find record in clean numeric df
    record_df = train_df.loc[train_df['UNITID'] == unit_id]

    # Standardize into array
    std_array = scaler.fit_transform(record_df)

    # Assign cluster for specific school
    prediction = kmeans.predict(std_array)
    return prediction

# Test function
# print(cluster_predict(100654))
```

[17]:

```
# Store cluster labels for each school into original df

# Create new column
df['CLUSTERLABEL'] = ""

# Assign cluster label for each school
df['CLUSTERLABEL']=df.apply(lambda x: cluster_predict(df['UNITID']), axis=0)

df.head()
```

[17]:

```
   Unnamed: 0  UNITID  SAT_AVG  ACT_MEDIAN  TUITION_OUT_ST  LOCALE   LATITUDE  \
0           1  100654      957          18           18354      12  34.783368
1           2  100663     1220          25           19704      12  33.505697
```

```
2           3  100690       0            0            6900        12  32.362609
3           4  100706    1314           28           22362        12  34.724557
4           5  100724     972           18           19396        12  32.364317

   LONGITUDE  ADM_RATE_ALL   SIZE  …  MEDIAN_PLUS_LN_DEBT_GRADS  \
0 -86.568502        0.8986   4990  …                    16106.0
1 -86.799345        0.9211  13186  …                    16954.0
2 -86.174010        1.0000    351  …                        NaN
3 -86.640449        0.8087   7458  …                    16550.0
4 -86.295677        0.9774   3903  …                    18952.0

   Y2_LN_DEFAULT_RT  Y2_LN_DELINQ_RT  FED_UG_PAIDINFULL  \
0          0.172640         0.074776           0.007926
1          0.060389         0.034483           0.059675
2          0.157191         0.050167                NaN
3          0.055035         0.031390           0.092947
4          0.173804         0.061713           0.007872

   UG_GRAD_2Y_FORBEAR_RT  LPSTAFFORD_CNT  NUM_STU_PLUS_LN_BAL  LPPPLUS_AMT  \
0               0.266409         31374.0                 5201  113949554.0
1               0.156121         56997.0                 3727   87421879.0
2               0.000000          4463.0                   16     309618.0
3               0.100349         19702.0                 1397   29789762.0
4               0.286976         34246.0                 4602   95359062.0

   FED_SCHOOL_CD  CLUSTERLABEL
0         001002            21
1         001052             5
2         016885            10
3         001055             5
4         001005            21

[5 rows x 50 columns]
```

[18]:

```python
# Function returns cluister label given a school id
def get_label(unit_id):

    rslt_df = df[df['UNITID'] == int(unit_id)]
    cluster_label = rslt_df.CLUSTERLABEL.iloc[0]

    return cluster_label

# Test function
# print('CLUSTER LABEL is: ', get_label(100706))
```

[19]:

```python
# Function returns school name given a unique school identifier
def get_school_name(unit_id):
    rslt_df = df[df['UNITID'] == int(unit_id)]

    school_name = rslt_df.SCHOOL_NAME.iloc[0]

    return school_name

# Test function
# print('SCHOOL NAME is: ', get_school_name(100706))
```

[20]:

```
# Given a unique school id, return a list of recommended schools in the same␣
 ↪cluster
# Note: To find recommendations for Penn State, use UNITID = 214777
unit_id = input('What is the school id of a college which interests you? ')

# Get cluster label for selected school
cluster_label = get_label(int(unit_id))

# Return school_names for all schools in the cluster
rslt_df = df[df['CLUSTERLABEL'] == cluster_label]


# Print output of recommendations
pd.options.display.max_rows = 3000
print('Since you like', get_school_name(unit_id), ', then you might also be␣
 ↪interested in these other schools.')
rslt_df.SCHOOL_NAME
```

```
What is the school id of a college which interests you? 214777
Since you like Pennsylvania State University-Main Campus , then you might also
be interested in these other schools.
```

[20]:

```
1308    Pennsylvania State University-Penn State Erie-…
1309    Pennsylvania State University-Penn State New K…
1310    Pennsylvania State University-Penn State Shenango
1311    Pennsylvania State University-Penn State Wilke…
1312    Pennsylvania State University-Penn State Scranton
1313    Pennsylvania State University-Penn State Lehig…
1314     Pennsylvania State University-Penn State Altoona
1315      Pennsylvania State University-Penn State Beaver
1316       Pennsylvania State University-Penn State Berks
1317    Pennsylvania State University-Penn State Harri…
1318    Pennsylvania State University-Penn State Brand…
1319    Pennsylvania State University-Penn State Fayet…
1320    Pennsylvania State University-Penn State Hazleton
1321             Pennsylvania State University-Main Campus
1322    Pennsylvania State University-Penn State Great…
```

```
1323    Pennsylvania State University-Penn State Mont …
1324    Pennsylvania State University-Penn State Abington
1325    Pennsylvania State University-Penn State Schuy…
1326        Pennsylvania State University-Penn State York
1770                        Arizona State University-West
1779                 Arizona State University-Polytechnic
1856            Arizona State University-Downtown Phoenix
1944           Pennsylvania State University-World Campus
1984                     Arizona State University-Skysong
Name: SCHOOL_NAME, dtype: object
```

```
[ ]:
```