fake_job_post_2

June 9, 2020

Prediction

This is a prediction part. And because of section description has sentences and paragraphs we needed to use natural language processing (NLP) toolkit. For using it, some libbraries need to download after every runtime.

[1]:
```
import nltk
nltk.download('popular')
```

```
[nltk_data] Downloading collection 'popular'
[nltk_data]    |
[nltk_data]    | Downloading package cmudict to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/cmudict.zip.
[nltk_data]    | Downloading package gazetteers to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/gazetteers.zip.
[nltk_data]    | Downloading package genesis to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/genesis.zip.
[nltk_data]    | Downloading package gutenberg to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/gutenberg.zip.
[nltk_data]    | Downloading package inaugural to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/inaugural.zip.
[nltk_data]    | Downloading package movie_reviews to
[nltk_data]    |     /root/nltk_data...
[nltk_data]    |   Unzipping corpora/movie_reviews.zip.
[nltk_data]    | Downloading package names to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/names.zip.
[nltk_data]    | Downloading package shakespeare to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/shakespeare.zip.
[nltk_data]    | Downloading package stopwords to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/stopwords.zip.
[nltk_data]    | Downloading package treebank to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/treebank.zip.
[nltk_data]    | Downloading package twitter_samples to
[nltk_data]    |     /root/nltk_data...
[nltk_data]    |   Unzipping corpora/twitter_samples.zip.
[nltk_data]    | Downloading package omw to /root/nltk_data...
```

```
[nltk_data]    |   Unzipping corpora/omw.zip.
[nltk_data]    | Downloading package wordnet to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/wordnet.zip.
[nltk_data]    | Downloading package wordnet_ic to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/wordnet_ic.zip.
[nltk_data]    | Downloading package words to /root/nltk_data...
[nltk_data]    |   Unzipping corpora/words.zip.
[nltk_data]    | Downloading package maxent_ne_chunker to
[nltk_data]    |     /root/nltk_data...
[nltk_data]    |   Unzipping chunkers/maxent_ne_chunker.zip.
[nltk_data]    | Downloading package punkt to /root/nltk_data...
[nltk_data]    |   Unzipping tokenizers/punkt.zip.
[nltk_data]    | Downloading package snowball_data to
[nltk_data]    |     /root/nltk_data...
[nltk_data]    | Downloading package averaged_perceptron_tagger to
[nltk_data]    |     /root/nltk_data...
[nltk_data]    |   Unzipping taggers/averaged_perceptron_tagger.zip.
[nltk_data]    |
[nltk_data]  Done downloading collection popular
```

[1]:
```
True
```

[2]:
```
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
%matplotlib inline
import numpy as np
pd.set_option('display.max_columns', None)

from nltk.corpus import stopwords
stop_words = stopwords.words('english')
from nltk.stem import WordNetLemmatizer
import string

import base64
import string
import re
from collections import Counter
from nltk.corpus import stopwords
stopwords = stopwords.words('english')

from sklearn.feature_extraction.text import CountVectorizer
from sklearn.base import TransformerMixin
from sklearn.pipeline import Pipeline
from sklearn.svm import LinearSVC
from sklearn.feature_extraction.stop_words import ENGLISH_STOP_WORDS
from sklearn.metrics import accuracy_score, roc_auc_score,␣
 ↪classification_report, confusion_matrix
```

```
from nltk.corpus import stopwords
import string
import re
import spacy
spacy.load('en_core_web_sm')
from spacy.lang.en import English
parser = English()
```

```
/usr/local/lib/python3.6/dist-packages/statsmodels/tools/_testing.py:19:
FutureWarning: pandas.util.testing is deprecated. Use the functions in the
public API at pandas.testing instead.
  import pandas.util.testing as tm
/usr/local/lib/python3.6/dist-packages/sklearn/utils/deprecation.py:144:
FutureWarning: The sklearn.feature_extraction.stop_words module is  deprecated
in version 0.22 and will be removed in version 0.24. The corresponding classes /
functions should instead be imported from sklearn.feature_extraction.text.
Anything that cannot be imported from sklearn.feature_extraction.text is now
part of the private API.
  warnings.warn(message, FutureWarning)
```

The main libraries used are stopwords (from stopwords) and spacy are used for eliminating the common words.

[0]:
```
df = pd.read_csv('/content/drive/My Drive/Colab Notebooks/Clean_data1.csv')
```

[5]:
```
df.shape
```

[5]:
```
(11272, 14)
```

[0]:
```
del df['Unnamed: 0']
```

[7]:
```
df.shape
```

[7]:
```
(11272, 13)
```

[0]:
```
df1 = df.copy()
```

[0]:
```
from sklearn.feature_extraction.text import CountVectorizer
from sklearn.model_selection import train_test_split
from sklearn.compose import ColumnTransformer
from sklearn import preprocessing
from sklearn.preprocessing import OneHotEncoder
from sklearn.feature_extraction.stop_words import ENGLISH_STOP_WORDS
```

[0]:
```
STOPLIST = set(stopwords.words('english') + list(ENGLISH_STOP_WORDS))
SYMBOLS = " ".join(string.punctuation).split(" ")
```

[0]:
```
def tokenizetext(sample):
    text = sample.strip().replace("\n", " ").replace("\r", " ")
    text = text.lower()
    tokens = parser(text)
    lemmas = []
    for tok in tokens:
```

```
        lemmas.append(tok.lemma_.lower().strip() if tok.lemma_ != "-PRON-" else␣
↪tok.lower_)
    tokens = lemmas
    tokens = [tok for tok in tokens if tok not in STOPLIST]
    tokens = [tok for tok in tokens if tok not in SYMBOLS]
    return tokens
```

This function is used for including each word from description into list form and also common english words, pronouns and sysmbols like dots and commas are also eliminated.

[0]:
```
vectorizer = CountVectorizer(tokenizer = tokenizetext, ngram_range = (1,3),␣
↪min_df = 0.06)
```

[0]:
```
vectorizer_features = vectorizer.fit_transform(df1['description'])
```

This CountVectorizer function from sklean converts the words into the vectors or features. Like one hot encoding.

[14]:
```
vectorizer_features.shape
```

[14]:
```
(11272, 666)
```

[15]:
```
vectorizer_features
```

[15]:
```
<11272x666 sparse matrix of type '<class 'numpy.int64'>'
        with 991737 stored elements in Compressed Sparse Row format>
```

[0]:
```
vectorized_df = pd.DataFrame(vectorizer_features.todense(), columns =␣
↪vectorizer.get_feature_names())
df_vectorized = pd.concat([df1, vectorized_df], axis = 1)
```

[0]:
```
df_vectorized.drop('description', axis = 1, inplace = True)
df_vectorized.dropna(inplace=True)
```

[0]:
```
df_vectorized.head()
```

There are large no of coloumns. While converting to pdf its taking lot of pages.

[0]:
```
columns_to_1_hot = ['employment_type', 'required_experience',␣
↪'required_education', 'industry', 'function']

for column in columns_to_1_hot:
    encoded = pd.get_dummies(df_vectorized[column])
    df_vectorized = pd.concat([df_vectorized, encoded], axis = 1)
```

Then other remaining features are converted to one hot encoding.

[0]:
```
columns_to_1_hot += ['title', 'city', 'country_name']
df_vectorized.drop(columns_to_1_hot, axis = 1, inplace = True)
```

Some features like title, city and country are eliminated because

---

title = this part is covered in description.

[0]:
```
target = df_vectorized['fraudulent']
features = df_vectorized.drop('fraudulent', axis = 1)

X_train, X_test, y_train, y_test = train_test_split(features, target, test_size␣
 ↪= 0.1, stratify = target, random_state=42)
```

[0]:
```
Model_Score = []
Model_Name = []
```

[0]:
```
from sklearn.model_selection import GridSearchCV

from sklearn.linear_model import LogisticRegression
from sklearn.neighbors import KNeighborsClassifier
from sklearn.svm import SVC
from sklearn.ensemble import RandomForestClassifier
from sklearn.neural_network import MLPClassifier

from sklearn.metrics import accuracy_score, confusion_matrix,␣
 ↪classification_report, roc_auc_score
```

Logistic Regresssion

First it is performed **without tuning hyperparameters**

[24]:
```
logmodel = LogisticRegression(max_iter = 20000)
logmodel.fit(X_train,y_train)
print('logreg')

#Predicting on the Test Set
predictions = logmodel.predict(X_test)

from sklearn.metrics import classification_report
print(classification_report(y_test, predictions))
```

```
logreg
              precision    recall  f1-score   support

           0       0.99      1.00      1.00      1103
           1       0.89      0.64      0.74        25

    accuracy                           0.99      1128
   macro avg       0.94      0.82      0.87      1128
weighted avg       0.99      0.99      0.99      1128
```

Then by using GridSearchCV function a 3 fold cross validation is done and also **tuned the hyperparameters**.

[0]:
```
log_reg = LogisticRegression()
c_values = [0.00001, 0.0001, 0.001, 0.01, 0.1, 1, 10, 100, 1000, 10000]
penalty_options = ['l1', 'l2']
```

```
param_grid = dict(C = c_values, penalty = penalty_options)
```

[0]:
```
grid_tfidf = GridSearchCV(log_reg, param_grid = param_grid, cv = 3, scoring =␣
↪'roc_auc', n_jobs = -1, verbose=1)
```

[27]:
```
grid_tfidf.fit(X_train, y_train)
```

```
Fitting 3 folds for each of 20 candidates, totalling 60 fits
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 2 concurrent workers.
[Parallel(n_jobs=-1)]: Done  46 tasks      | elapsed:   18.0s
[Parallel(n_jobs=-1)]: Done  60 out of  60 | elapsed:   25.7s finished
```

[27]:
```
GridSearchCV(cv=3, error_score=nan,
             estimator=LogisticRegression(C=1.0, class_weight=None, dual=False,
                                          fit_intercept=True,
                                          intercept_scaling=1, l1_ratio=None,
                                          max_iter=100, multi_class='auto',
                                          n_jobs=None, penalty='l2',
                                          random_state=None, solver='lbfgs',
                                          tol=0.0001, verbose=0,
                                          warm_start=False),
             iid='deprecated', n_jobs=-1,
             param_grid={'C': [1e-05, 0.0001, 0.001, 0.01, 0.1, 1, 10, 100,
                               1000, 10000],
                         'penalty': ['l1', 'l2']},
             pre_dispatch='2*n_jobs', refit=True, return_train_score=False,
             scoring='roc_auc', verbose=1)
```

[0]:
```
log_reg_pred = grid_tfidf.predict(X_test)
```

[49]:
```
print (roc_auc_score(y_test, log_reg_pred))
print (classification_report(y_test, log_reg_pred))
```

```
0.7795466908431551
              precision    recall  f1-score   support

           0       0.99      1.00      0.99      1103
           1       0.93      0.56      0.70        25

    accuracy                           0.99      1128
   macro avg       0.96      0.78      0.85      1128
weighted avg       0.99      0.99      0.99      1128
```

Even though data of fraudelent = 1 is less, it gives good precision and f1 score.

[0]:
```
Model_Name.append('Logistic_Regression')
Model_Score.append(round(roc_auc_score(y_test, log_reg_pred), 4))
```

KNN

[31]:
```
knn = KNeighborsClassifier()
k_range = list(np.arange(2, 10, 2))
param_grid_knn = dict(n_neighbors = k_range)
print (param_grid_knn)
```

```
{'n_neighbors': [2, 4, 6, 8]}
```

[0]:
```
grid_knn = GridSearchCV(knn, param_grid_knn, cv = 3, scoring = 'roc_auc',␣
↪n_jobs = -1, verbose = 1)
```

[33]:
```
grid_knn.fit(X_train, y_train)
```

```
Fitting 3 folds for each of 4 candidates, totalling 12 fits
```

```
[Parallel(n_jobs=-1)]: Using backend LokyBackend with 2 concurrent workers.
[Parallel(n_jobs=-1)]: Done  12 out of  12 | elapsed:  4.4min finished
```

[33]:
```
GridSearchCV(cv=3, error_score=nan,
             estimator=KNeighborsClassifier(algorithm='auto', leaf_size=30,
                                            metric='minkowski',
                                            metric_params=None, n_jobs=None,
                                            n_neighbors=5, p=2,
                                            weights='uniform'),
             iid='deprecated', n_jobs=-1,
             param_grid={'n_neighbors': [2, 4, 6, 8]}, pre_dispatch='2*n_jobs',
             refit=True, return_train_score=False, scoring='roc_auc',
             verbose=1)
```

[34]:
```
grid_knn.best_score_
```

[34]:
```
0.9331061452522008
```

[35]:
```
grid_knn.best_params_
```

[35]:
```
{'n_neighbors': 8}
```

[0]:
```
knn_pred = grid_knn.predict(X_test)
```

[37]:
```
print (roc_auc_score(y_test, knn_pred))
print (classification_report(y_test, knn_pred))
```

```
0.72
              precision    recall  f1-score   support

           0       0.99      1.00      0.99      1103
           1       1.00      0.44      0.61        25

    accuracy                           0.99      1128
   macro avg       0.99      0.72      0.80      1128
weighted avg       0.99      0.99      0.99      1128
```

[0]:
```
Model_Name.append('KNN')
Model_Score.append(round(roc_auc_score(y_test, knn_pred), 4))
```

SVC

[39]:
```
svc = SVC()
kernel = ['linear', 'rbf']
param_grid_knn = dict(kernel = kernel)
print (param_grid_knn)
```

```
{'kernel': ['linear', 'rbf']}
```

[0]:
```
grid_svc = GridSearchCV(svc, param_grid_knn, cv = 3, scoring = 'roc_auc',␣
↪n_jobs = -1, verbose = 2)
```

[41]:
```
grid_svc.fit(X_train, y_train)
```

```
Fitting 3 folds for each of 2 candidates, totalling 6 fits

[Parallel(n_jobs=-1)]: Using backend LokyBackend with 2 concurrent workers.
[Parallel(n_jobs=-1)]: Done   6 out of   6 | elapsed:   31.9s finished
```

[41]:
```
GridSearchCV(cv=3, error_score=nan,
             estimator=SVC(C=1.0, break_ties=False, cache_size=200,
                           class_weight=None, coef0=0.0,
                           decision_function_shape='ovr', degree=3,
                           gamma='scale', kernel='rbf', max_iter=-1,
                           probability=False, random_state=None, shrinking=True,
                           tol=0.001, verbose=False),
             iid='deprecated', n_jobs=-1,
             param_grid={'kernel': ['linear', 'rbf']}, pre_dispatch='2*n_jobs',
             refit=True, return_train_score=False, scoring='roc_auc',
             verbose=2)
```

[42]:
```
grid_svc.best_score_
```

[42]:
```
0.9739281333637583
```

[43]:
```
grid_svc.best_params_
```

[43]:
```
{'kernel': 'linear'}
```

[0]:
```
svc_pred = grid_svc.predict(X_test)
```

[45]:
```
print (roc_auc_score(y_test, svc_pred))
print (classification_report(y_test, svc_pred))
```

```
0.8195466908431551
              precision    recall  f1-score   support

           0       0.99      1.00      1.00      1103
```

```
           1       0.94      0.64      0.76        25

    accuracy                           0.99      1128
   macro avg       0.97      0.82      0.88      1128
weighted avg       0.99      0.99      0.99      1128
```

[0]:
```
Model_Name.append('SVC')
Model_Score.append(round(roc_auc_score(y_test, svc_pred), 4))
```

MLP Classifier

[0]:
```
mlp = MLPClassifier(solver = 'sgd', activation = 'relu', hidden_layer_sizes =␣
↪(100, 50, 30), max_iter = 1000)
```

[48]:
```
mlp.fit(X_train, y_train)
```

[48]:
```
MLPClassifier(activation='relu', alpha=0.0001, batch_size='auto', beta_1=0.9,
              beta_2=0.999, early_stopping=False, epsilon=1e-08,
              hidden_layer_sizes=(100, 50, 30), learning_rate='constant',
              learning_rate_init=0.001, max_fun=15000, max_iter=1000,
              momentum=0.9, n_iter_no_change=10, nesterovs_momentum=True,
              power_t=0.5, random_state=None, shuffle=True, solver='sgd',
              tol=0.0001, validation_fraction=0.1, verbose=False,
              warm_start=False)
```

[51]:
```
mlp_pred = mlp.predict(X_test)
print (roc_auc_score(y_test, mlp_pred))
print (classification_report(y_test, mlp_pred))
```

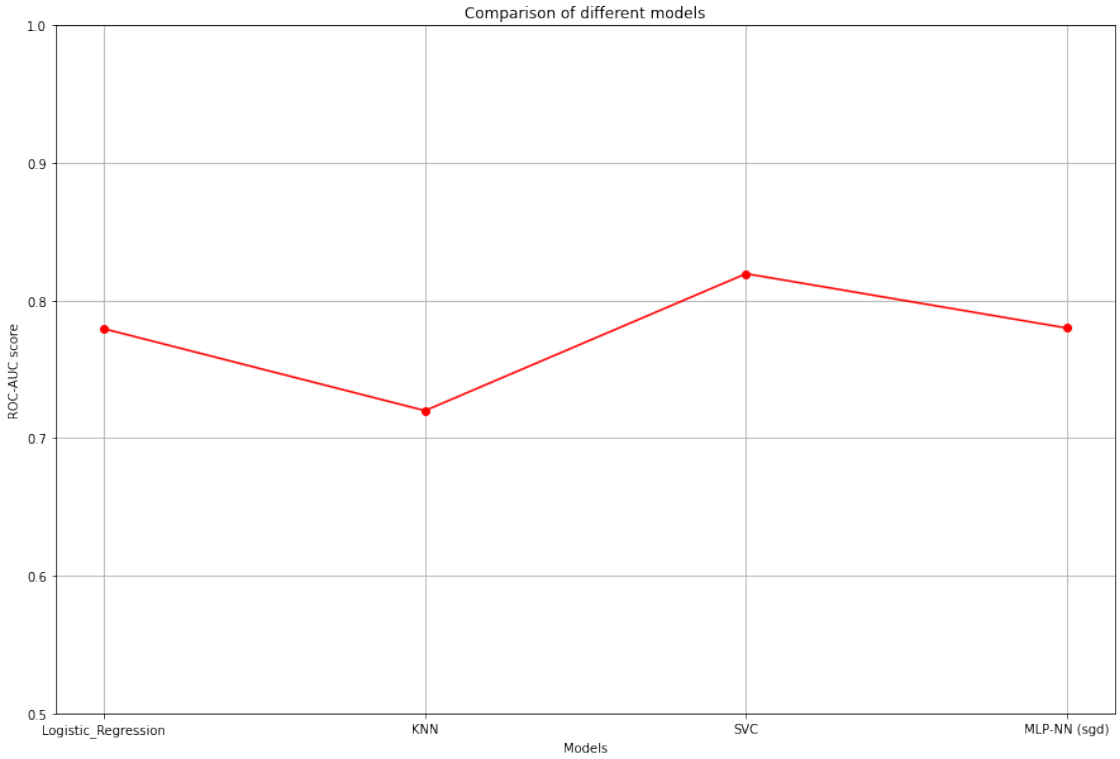
```
0.78
              precision    recall  f1-score   support

           0       0.99      1.00      1.00      1103
           1       1.00      0.56      0.72        25

    accuracy                           0.99      1128
   macro avg       1.00      0.78      0.86      1128
weighted avg       0.99      0.99      0.99      1128
```

[0]:
```
Model_Name.append('MLP-NN (sgd)')
Model_Score.append(round(roc_auc_score(y_test, mlp_pred), 4))
```

Model Comparison

[59]:
```
plt.figure(figsize = (15, 10))
plt.plot(Model_Name,Model_Score, marker = 'o', color = 'red')
plt.title('Comparison of different models')
plt.xlabel('Models')
plt.ylabel('ROC-AUC score')
```

```
plt.ylim(0.5, 1.0)
plt.grid()
plt.savefig('Model_compare.jpeg')
plt.show()
```



[0]: