Language Detection - Nepali / Hindi.

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- Here, we deploy classification algorithms like Naive Bayes Model, Random For
  Regression to identify whether the given language is Nepali (0) or Hindi(1).
- The Vectorizer used is TFIDF.
- The hyperparameters are tuned using RandomizedSearchCV.

Importing necessary libraries.

In [1]:
```
import os
import pickle
import pandas as pd
import numpy as np
import re
```

In [2]:
```
os.chdir(r'C:\Users\acer\Desktop\PythonProgramming\Nepali_Hindi Language Classifi
```

Loading the pickled files that contain cleaned texts.

In [3]:
```
nepali_df = pickle.load(open('nepali_sample_cleaned.pkl', 'rb'))
hindi_df = pickle.load(open('hindi_sample_cleaned.pkl', 'rb'))
```

Adding labels to the dataframe as Nepali / Hindi.

- Nepali: 0
- Hindi: 1

In [4]:
```
nepali_df['label'] = np.zeros(nepali_df.shape[0])
hindi_df['label'] = np.ones(hindi_df.shape[0])
```

```
In [5]: nepali_df['label'] = nepali_df.label.astype(int)
        hindi_df['label'] = hindi_df.label.astype(int)
```

Merging the two dataframes.

```
In [6]: merged_df = pd.concat([nepali_df, hindi_df], ignore_index=True)
```

```
In [7]: df = merged_df.copy()
```

Shuffling the dataframe rows.

```
In [8]: def shuffle(dataframe, random_state = 100):
            dd = dataframe.copy()
            dd = dd.sample(frac = 1, random_state = 100)
            dd.reset_index(drop = True, inplace = True)
            return dd
```

In [9]:

```
df = shuffle(df, 42)
df.head(20)
```

	0	label
0	फ्लैशबैक	1
1	रंगदारी गोलीकांड पुलिस के हाथ खाली	1
2	एमाले अध्यक्ष केपी ओली दोस्रो पटक प्रधानमन्त्र...	0
3	भूमि व्यवस्था सहकारी तथा गरिबी निवारणमन्त्री प...	0
4	हाम्रा जनप्रतिनिधि र सरकारी संयन्त्र कतिसम्म अ...	0
5	भारतीय प्रधानमन्त्री नरेन्द्र मोदीले प्रधानमन्...	0
6	तपाईको प्रतिक्रिया समीक्षामा भएकोले प्रकाशित भ...	0
7	नेपाल मजदुर किसान पार्टीका सांसद प्रेम सुवालले...	0
8	मजदूरों से भरा ऑटो पलटा एक मरा जख्मी	1
9	आफू महाअभियोग प्रस्ताव दर्ता हुनु केही समय अगा...	0
10	मान्छेको अर्थतन्त्रमा सहर घुसेको झन्डै वर्ष भ...	0
11	कहीं पाताल में तो कहीं फर्श पर पहुंचा पानी	1
12	कांग्रेस सभापति शेरबहादुर देउवा सबै पदाधिकारी ...	0
13	यो वेबसाइट कान्तिपुर राष्ट्रिय दैनिकको आधिकारि...	0
14	डंपिंग ग्राउंड की शिफ्टिंग को लेकर विधायक ने स...	1
15	पाक का नया पैंतरा आईसीजे में डाली पुनर्विचार ...	1
16	बेटे की फीस भरने में नाकाम रहने पर की थी फायरिंग	1
17	वारदात स्थल पर पहुंचते ही सदमे में आई पीड़िता ...	1
18	हर खुशी पर जरूर करें पौधरोपण	1
19	तंवर ने किया सामुदायिक स्वास्थ्य केंद्र का दौरा	1

In [10]:

```
df.shape
```

```
(40000, 2)
```

Train - Test Split.

In [11]:

```
from sklearn.model_selection import train_test_split, RandomizedSearchCV
```

In [12]:

```
# Dependent and Independent Features.
X = df.iloc[:, 0].values
y = df.iloc[:, 1].values
```

In [13]:

```
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size = .2, random_
```

Vectorizing the texts using TFIDF Vectorizer.

In [14]:

```
from sklearn.feature_extraction.text import TfidfVectorizer as TFIDF
```

In [15]:

```
tfidf = TFIDF(ngram_range=(1,3))
```

In [16]:

```
X_train_vectorized = tfidf.fit_transform(X_train)
X_test_vectorized = tfidf.transform(X_test)
```

Classification using Multinomial Bayes.

In [17]:

```
from sklearn.naive_bayes import MultinomialNB
```

In [18]:

```
classifier_NB = MultinomialNB()
```

In [19]:

```
params_for_random_search = {'alpha':[.00001, .0001, .001, .01, .1, 1.0],
                           'fit_prior': [True, False]}
```

In [20]:

```
model = RandomizedSearchCV(estimator= classifier_NB,
                           param_distributions= params_for_random_search,
                           n_iter= 75,
                           n_jobs=1,
                           random_state=42,
                           cv = 5,
                           return_train_score= False
                          )
```

In [21]:

```
model.fit(X_train_vectorized, y_train)
```

```
C:\Users\acer\PycharmProjects\untitled\venv\lib\site-packages\sklearn\model_selection\_search.py:266: U
meters 12 is smaller than n_iter=75. Running 12 iterations. For exhaustive searches, use GridSearchCV.
  % (grid_size, self.n_iter, grid_size), UserWarning)
```

```
RandomizedSearchCV(cv=5, error_score='raise-deprecating',
                   estimator=MultinomialNB(alpha=1.0, class_prior=None,
                                           fit_prior=True),
                   iid='warn', n_iter=75, n_jobs=1,
                   param_distributions={'alpha': [1e-05, 0.0001, 0.001, 0.01,
                                                  0.1, 1.0],
                                        'fit_prior': [True, False]},
                   pre_dispatch='2*n_jobs', random_state=42, refit=True,
                   return_train_score=False, scoring=None, verbose=0)
```

In [22]:

```
results_NB = pd.DataFrame(model.cv_results_)
results_NB
```

	mean_fit_time	std_fit_time	mean_score_time	std_score_time	param_fit_prior	param_alp
0	0.085780	0.013989	0.015797	0.003059	True	1e-05
1	0.066986	0.001789	0.012395	0.000489	False	1e-05
2	0.080182	0.008399	0.017197	0.004353	True	0.0001
3	0.068984	0.002097	0.013597	0.000801	False	0.0001
4	0.069577	0.000788	0.013196	0.000400	True	0.001
5	0.068583	0.003498	0.012999	0.001549	False	0.001
6	0.067984	0.002190	0.012399	0.000489	True	0.01
7	0.071184	0.001938	0.013397	0.000802	False	0.01
8	0.069585	0.000490	0.011996	0.000632	True	0.1
9	0.068585	0.000490	0.013196	0.000400	False	0.1
10	0.068784	0.005305	0.012403	0.000497	True	1
11	0.068575	0.001015	0.013197	0.000747	False	1

In [23]:

```
print(model.best_params_)
```

```
{'fit_prior': False, 'alpha': 0.01}
```

In [24]:

```
print(model.best_score_)
```

```
0.9705625
```

In [25]:

```
print(model.best_index_)
# The index (of the cv_results_ arrays) which corresponds to the best candidate p
```

```
7
```

In [26]:

```
model.best_estimator_
```

```
MultinomialNB(alpha=0.01, class_prior=None, fit_prior=False)
```

Selecting the best estimator.

In [27]:

```
classifier_new = model.best_estimator_
classifier_new.fit(X_train_vectorized, y_train)
```

```
MultinomialNB(alpha=0.01, class_prior=None, fit_prior=False)
```

In [28]:

```
predictions = classifier_new.predict(X_test_vectorized)
```

Confusion Matrix:

In [29]:

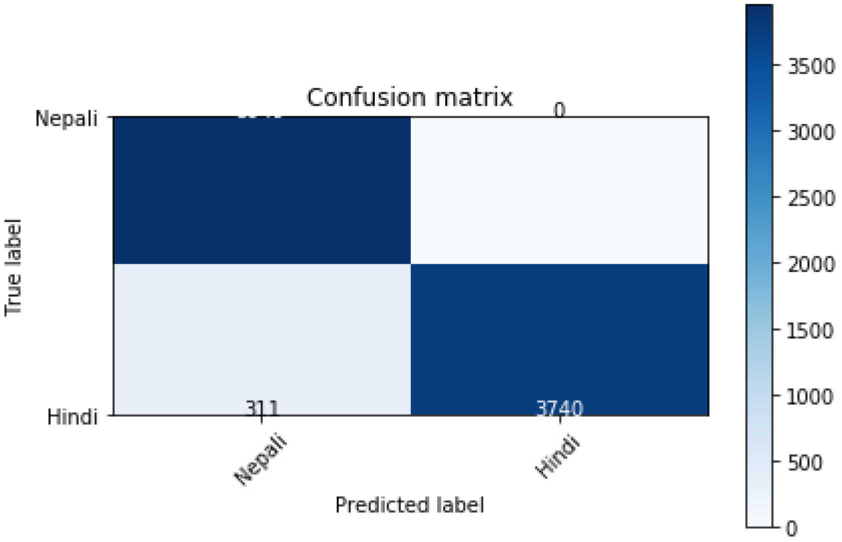
```
from sklearn import metrics
import itertools
import matplotlib.pyplot as plt
```

In [30]:

```
def plot_confusion_matrix(cm, classes,
                          normalize=False,
                          title='Confusion matrix',
                          cmap=plt.cm.Blues):
    """
    See full source and example:
    http://scikit-learn.org/stable/auto_examples/model_selection/plot_confusion_m

    This function prints and plots the confusion matrix.
    Normalization can be applied by setting `normalize=True`.
    """
    plt.imshow(cm, interpolation='nearest', cmap=cmap)
    plt.title(title)
    plt.colorbar()
    tick_marks = np.arange(len(classes))
    plt.xticks(tick_marks, classes, rotation=45)
    plt.yticks(tick_marks, classes)

    if normalize:
        cm = cm.astype('float') / cm.sum(axis=1)[:, np.newaxis]
        print("Normalized confusion matrix")
    else:
        print('Confusion matrix, without normalization')

    thresh = cm.max() / 2.
    for i, j in itertools.product(range(cm.shape[0]), range(cm.shape[1])):
        plt.text(j, i, cm[i, j],
                 horizontalalignment="center",
                 color="white" if cm[i, j] > thresh else "black")

    plt.tight_layout()
    plt.ylabel('True label')
    plt.xlabel('Predicted label')
```

```
In [31]: cm = metrics.confusion_matrix(y_test, predictions)
         plot_confusion_matrix(cm, classes=['Nepali', 'Hindi'])
```

```
Confusion matrix, without normalization
```



Model Performance:

In [32]:

```
def accuracy_check(print_values = True):
    if print_values == True:
        print('Accuracy (in %) = ',round(float(metrics.accuracy_score(y_test, pre
        print('ROC - AUC Score (in %) = ',round(float(metrics.roc_auc_score(y_tes
        print('F1 - Score (in %) = ',round(float(metrics.f1_score(y_test, predict

    '''acc_dict = dict()
    acc_dict['Accuracy Score'] = metrics.accuracy_score(y_test, predictions
    acc_dict['ROC - AUC Score'] = metrics.roc_auc_score(y_test, predictions)
    acc_dict['F1 - Score'] = metrics.f1_score(y_test, predictions) '''
    return (round(float(metrics.accuracy_score(y_test, predictions) ) *100, 2),
            round(float(metrics.roc_auc_score(y_test, predictions) ) *100, 2),
            round(float(metrics.f1_score(y_test, predictions) ) *100, 2)
           )
```

In [33]:

```
accuracy_check()
```

```
Accuracy (in %) =  96.11 %
ROC - AUC Score (in %) =  96.16 %
F1 - Score (in %) =  96.01 %
```

```
(96.11, 96.16, 96.01)
```

The results are fairly accurate using Naive bayes Model. Let's see if we can improv Random Forest and Logistic Regression.

Classification using Random Forest.

In [34]:

```
from sklearn.ensemble import RandomForestClassifier
```

In [35]:

```
classifier_RF = RandomForestClassifier()
```

In [36]:

```
parameters = {'n_estimators': [4, 6, 9],
              'max_features': ['log2', 'sqrt','auto'],
              'criterion': ['entropy', 'gini'],
              'max_depth': [2, 3, 5, 10],
              'min_samples_split': [2, 3, 5],
              'min_samples_leaf': [1,5,8]
             }
```

In [37]:

```
model1 = RandomizedSearchCV(estimator= classifier_RF,
                            param_distributions= parameters,
                            n_iter= 75,
                            n_jobs=1,
                            random_state=42,
                            cv = 5,
                            return_train_score= False
                           )
```

In [38]:

```
model1.fit(X_train_vectorized, y_train)
```

```
RandomizedSearchCV(cv=5, error_score='raise-deprecating',
                   estimator=RandomForestClassifier(bootstrap=True,
                                                    class_weight=None,
                                                    criterion='gini',
                                                    max_depth=None,
                                                    max_features='auto',
                                                    max_leaf_nodes=None,
                                                    min_impurity_decrease=0.0,
                                                    min_impurity_split=None,
                                                    min_samples_leaf=1,
                                                    min_samples_split=2,
                                                    min_weight_fraction_leaf=0.0,
                                                    n_estimators='warn',
                                                    n_jobs=None,
                                                    oob_sc...
                                                    random_state=None,
                                                    verbose=0,
                                                    warm_start=False),
                   iid='warn', n_iter=75, n_jobs=1,
                   param_distributions={'criterion': ['entropy', 'gini'],
                                        'max_depth': [2, 3, 5, 10],
                                        'max_features': ['log2', 'sqrt',
                                                         'auto'],
                                        'min_samples_leaf': [1, 5, 8],
                                        'min_samples_split': [2, 3, 5],
                                        'n_estimators': [4, 6, 9]},
                   pre_dispatch='2*n_jobs', random_state=42, refit=True,
                   return_train_score=False, scoring=None, verbose=0)
```

Fitting into the best model.

In [39]:

```
classifier_new = model1.best_estimator_
classifier_new.fit(X_train_vectorized, y_train)
```

```
RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gini',
                       max_depth=10, max_features='auto', max_leaf_nodes=None,
                       min_impurity_decrease=0.0, min_impurity_split=None,
                       min_samples_leaf=8, min_samples_split=3,
                       min_weight_fraction_leaf=0.0, n_estimators=6,
                       n_jobs=None, oob_score=False, random_state=None,
                       verbose=0, warm_start=False)
```

In [40]:

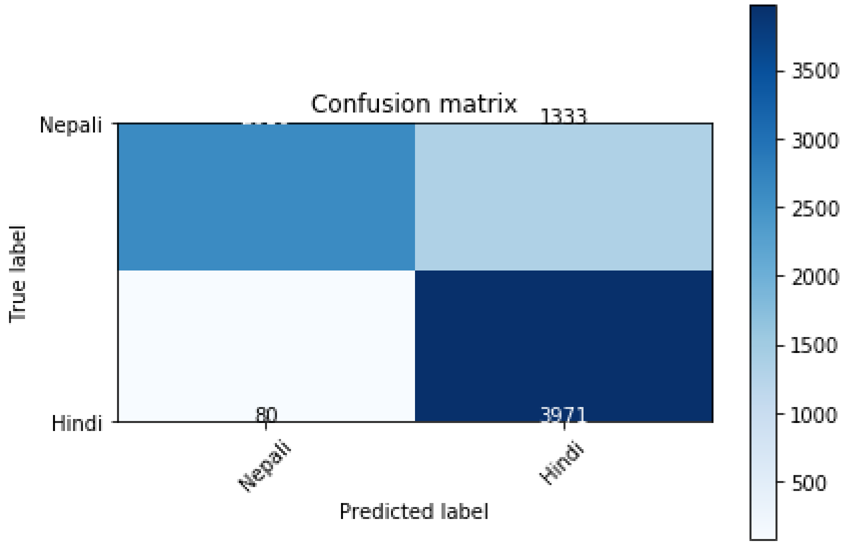
```
predictions = classifier_new.predict(X_test_vectorized)
```

Confusion Matrix.

In [41]:

```
cm = metrics.confusion_matrix(y_test, predictions)
plot_confusion_matrix(cm, classes=['Nepali', 'Hindi'])
```

```
Confusion matrix, without normalization
```



Model Performance:

In [42]:

```
accuracy_check()
```

```
Accuracy (in %) =  82.34 %
ROC - AUC Score (in %) =  82.13 %
F1 - Score (in %) =  84.9 %
```

```
(82.34, 82.13, 84.9)
```

Random Forest Classifier doesn't do well compared to Naive Bayes Classifi

---

Classification using Logistic Regression.

In [43]:

```
from sklearn.linear_model import LogisticRegression
```

In [44]:

```
classifier_LR = LogisticRegression()
```

In [45]:

```
parameters_for_logistic_regession = {'C': [1/100, 1/10, 1, 10, 100], 'fit_interce
```

In [46]:

```
model2 = RandomizedSearchCV(estimator= classifier_LR,
                            param_distributions= parameters_for_logistic_regessior
                            n_iter= 75,
                            n_jobs=1,
                            random_state=42,
                            cv = 5,
                            return_train_score= False
                           )
```

In [47]:

```
model2.fit(X_train_vectorized, y_train)
```

```
C:\Users\acer\PycharmProjects\untitled\venv\lib\site-packages\sklearn\model_selection\_search.py:266: U
meters 10 is smaller than n_iter=75. Running 10 iterations. For exhaustive searches, use GridSearchCV.
  % (grid_size, self.n_iter, grid_size), UserWarning)
C:\Users\acer\PycharmProjects\untitled\venv\lib\site-packages\sklearn\linear_model\logistic.py:432: Fut
changed to 'lbfgs' in 0.22. Specify a solver to silence this warning.
  FutureWarning)
```

```
RandomizedSearchCV(cv=5, error_score='raise-deprecating',
                   estimator=LogisticRegression(C=1.0, class_weight=None,
                                                dual=False, fit_intercept=True,
                                                intercept_scaling=1,
                                                l1_ratio=None, max_iter=100,
                                                multi_class='warn', n_jobs=None,
                                                penalty='l2', random_state=None,
                                                solver='warn', tol=0.0001,
                                                verbose=0, warm_start=False),
                   iid='warn', n_iter=75, n_jobs=1,
                   param_distributions={'C': [0.01, 0.1, 1, 10, 100],
                                        'fit_intercept': [True, False]},
                   pre_dispatch='2*n_jobs', random_state=42, refit=True,
                   return_train_score=False, scoring=None, verbose=0)
```

Fitting into the best model.

In [49]:

```
classifier_new = model2.best_estimator_
classifier_new.fit(X_train_vectorized, y_train)
```

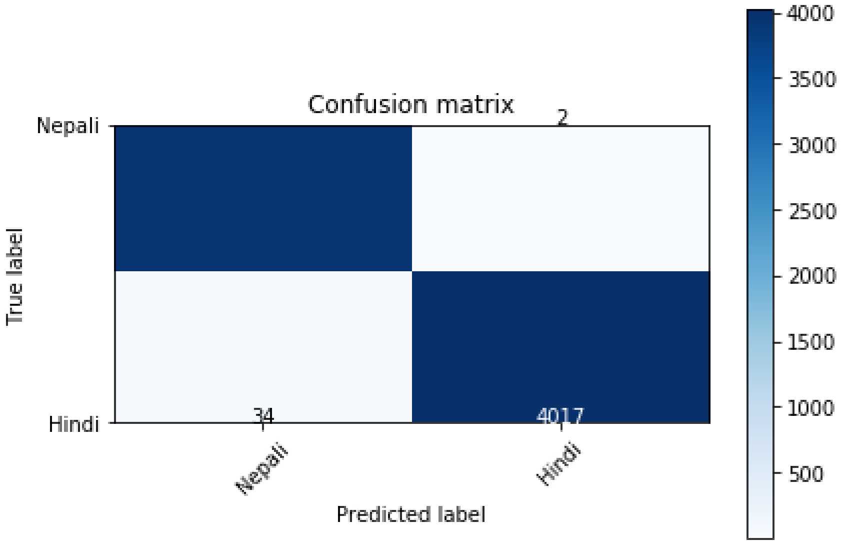
```
LogisticRegression(C=100, class_weight=None, dual=False, fit_intercept=True,
                   intercept_scaling=1, l1_ratio=None, max_iter=100,
                   multi_class='warn', n_jobs=None, penalty='l2',
                   random_state=None, solver='warn', tol=0.0001, verbose=0,
                   warm_start=False)
```

```
In [50]: predictions = classifier_new.predict(X_test_vectorized)
```

Confusion Matrix.

```
In [51]: cm = metrics.confusion_matrix(y_test, predictions)
         plot_confusion_matrix(cm, classes=['Nepali', 'Hindi'])
```

```
Confusion matrix, without normalization
```



Model Performance:

```
In [52]: accuracy_check()
```

```
Accuracy (in %) =  99.55 %
ROC - AUC Score (in %) =  99.56 %
F1 - Score (in %) =  99.55 %


(99.55, 99.56, 99.55)
```

Hence, the best classifier is the Logistic Regression with C = 100.

Testing with external TEXT.

```
In [53]: test_nepali =['क्तपुरको मध्यपुरथिमी नगरपालिका १ का वडाध्यक्ष सुरज खड्का लकडाउनका बेला पनि
         सरकारी संरचनाको सबैभन्दा तल्लो निकाय वडा कार्यालयको प्रमुख भएका नाताले अहिल उनको व्यस्तता बढे
```

```
In [54]: classifier_new.predict(tfidf.transform(test_nepali))
```

```
array([0])
```

```
In [55]: test_hindi = ['संदिग्ध हालत में युवती लापता अज्ञात पर अगवा करने का केस दर्ज']
```

```
In [56]: classifier_new.predict(tfidf.transform(test_hindi))
```

```
array([1])
```

Pickling the finalized optimum model into disk.¶

```
In [57]: pickle.dump(classifier_new, open('Logistic_regression_model.sav', 'wb'))
```

The End.