

4_train_classifiers_example

March 13, 2023

1 Train classification models for misinformation detection

1.1 Initialize

```
[2]: #####  
# Import libraries  
#####  
  
import pandas as pd  
import numpy as np  
import regex as re  
from collections import Counter  
from datetime import date  
from tqdm import tqdm  
import emoji  
  
import nltk  
from nltk import word_tokenize, sent_tokenize  
from nltk.corpus import stopwords  
from nltk.stem import WordNetLemmatizer  
nltk.download('punkt')  
nltk.download('stopwords')  
nltk.download('wordnet')  
  
stemmer = WordNetLemmatizer()  
  
from pandas.plotting import scatter_matrix  
import matplotlib.pyplot as plt  
  
import joblib  
import csv  
  
from sklearn.datasets import load_files  
from sklearn.feature_extraction.text import CountVectorizer, TfidfVectorizer  
  
from sklearn.metrics import classification_report, confusion_matrix,  
    ↪ accuracy_score  
from sklearn.tree import DecisionTreeClassifier
```

```

from sklearn.neighbors import KNeighborsClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.naive_bayes import MultinomialNB
from sklearn.linear_model import LogisticRegression
from sklearn.neural_network import MLPClassifier
from sklearn.svm import SVC
from sklearn.model_selection import cross_val_score, cross_val_predict, \
    train_test_split, KFold

from imblearn.over_sampling import RandomOverSampler
from imblearn.under_sampling import RandomUnderSampler

import glob

```

```

[nltk_data] Downloading package punkt to /home/app59/nltk_data...
[nltk_data] Package punkt is already up-to-date!
[nltk_data] Downloading package stopwords to /home/app59/nltk_data...
[nltk_data] Package stopwords is already up-to-date!
[nltk_data] Downloading package wordnet to /home/app59/nltk_data...
[nltk_data] Package wordnet is already up-to-date!

```

1.2 Load & inspect data

1.2.1 Define filepaths

```

[3]: thisday = date.today().strftime("%m%d%y")

# Multiple labeled data files for each myth
fvg_fps = [fp for fp in glob.glob('../data/samples/5G/*') if
            (fp.endswith('labeled.csv'))
            ]
neg_fvg_fps = [fp for fp in glob.glob('../data/samples/5G/negative_cases/*') if
               (fp.endswith('labeled.csv'))
               ]

msq_fps = [fp for fp in glob.glob('../data/samples/mosquitoes/*') if
            (fp.endswith('labeled.csv'))
            ]
neg_msq_fps = [fp for fp in glob.glob('../data/samples/5G/negative_cases/*') if
               (fp.endswith('labeled.csv'))
               ]

fvg_vec_fp = f'../models/vectorizer_5G_{str(thisday)}.joblib'
msq_vec_fp = f'../models/vectorizer_mosquitoes_{str(thisday)}.joblib'

```

1.2.2 Load & rename data

```
[4]: # For multiple files holding labeled data, load each one and add to empty DF

# Mosquitoes
msq_df = pd.DataFrame() # initialize
for fp in msq_fps:
    temp = pd.read_csv(fp, low_memory=False) # read file
    msq_df = pd.concat([msq_df, temp]) # add positive tweets to main DF
#add negative tweets
for fp in neg_fvg_fps:
    temp = pd.read_csv(fp, low_memory=False) # read file
    temp = temp[temp.myth_score == 1.0] # keep only negative tweets with score
    ↪ of 1.0 for other myth
    temp = temp.assign(myth_score = 0, myth_supports_score = 0) # change myth
    ↪ scores to zero
    temp = temp.assign(is_myth = "no", is_myth_supports = "no") # change myth
    ↪ labels to "no"
    msq_df = pd.concat([msq_df, temp]) # add negative tweets to main df

# 5G
fvg_df = pd.DataFrame() # initialize
for fp in fvg_fps:
    temp = pd.read_csv(fp, low_memory=False) # read file
    fvg_df = pd.concat([fvg_df, temp]) # add positive tweets to main DF
#add negative tweets
for fp in neg_fvg_fps:
    temp = pd.read_csv(fp, low_memory=False) # read file
    temp = temp[temp.myth_score == 1.0] # keep only negative tweets with score
    ↪ of 1.0 for other myth
    temp = temp.assign(myth_score = 0, myth_supports_score = 0) # change myth
    ↪ scores to zero
    temp = temp.assign(is_myth = "no", is_myth_supports = "no") # change myth
    ↪ labels to "no"
    fvg_df = pd.concat([fvg_df, temp]) # add negative tweets to main df

# Rename each DF's myth columns for clarity
msq_df = msq_df.reset_index(drop=True).rename(
    copy = False, columns =
    {'is_myth': 'msq_is_myth', 'myth_score': 'msq_myth_score',
     'is_myth_supports': 'msq_is_myth_supports', 'myth_supports_score':
     ↪ 'msq_myth_supports_score'})

fvg_df = fvg_df.reset_index(drop=True).rename(
    copy = False, columns =
    {'is_myth': 'fvg_is_myth', 'myth_score': 'fvg_myth_score',
```

```
'is_myth_supports': 'fvg_is_myth_supports', 'myth_supports_score':
↳ 'fvg_myth_supports_score'})
```

```
msq_df.tail(10)
```

```
[4]:      tweet_id      text \
1238  1.256274e+18  @USER01 @USER02 #Covid19 was created in a Cana...
1239  1.270119e+18  The #Covid scare was an engineered hoax. Someo...
1240  1.279824e+18  Sir Richard Dearlove stressed the fact that th...
1241  1.237855e+18  @USER01 Except, this time they have the engine...
1242  1.281818e+18  @USER01 @USER02 :confused_face::thinking_face:...
1243  1.236012e+18  Former IDF intelligence officer and expert on b...
1244  1.252298e+18  <em>URL01 Removed</em> Bioweapon 911- looking ...
1245  1.250571e+18  @USER01 @USER02 Gates & Fauci are behind t...
1246  1.246429e+18  Weapon's Name: Human Spit Bio Gun \nWeapon cla...
1247  1.251635e+18  Did China Just Admit the Obama Administration ...

      msq_is_myth  msq_myth_score  msq_is_myth_supports  msq_myth_supports_score
1238          no             0.0              no             0.0
1239          no             0.0              no             0.0
1240          no             0.0              no             0.0
1241          no             0.0              no             0.0
1242          no             0.0              no             0.0
1243          no             0.0              no             0.0
1244          no             0.0              no             0.0
1245          no             0.0              no             0.0
1246          no             0.0              no             0.0
1247          no             0.0              no             0.0
```

1.2.3 Summarize the numerical data

```
[5]: # Look at the number of instances of each is_myth class distribution
print(msq_df.groupby('msq_is_myth').size())
print()
print(fvg_df.groupby('fvg_is_myth').size())
print()

# Look at the number of instances of each is_myth_supports class distribution
print(msq_df.groupby('msq_is_myth_supports').size())
print()
print(fvg_df.groupby('fvg_is_myth_supports').size())
print()
```

```
msq_is_myth
no          678
unsure       7
yes         563
```

```

dtype: int64

fvg_is_myth
no          526
unsure      11
yes         587
dtype: int64

msq_is_myth_supports
no          930
unsure      254
yes         64
dtype: int64

fvg_is_myth_supports
no          861
unsure      133
yes         130
dtype: int64

```

1.3 Preprocess tweet text

1.3.1 Tweet Preprocessing

```

[6]: def process_tweets(tweet):
    '''
    Preprocesses raw text of a tweet, skipping any retweets.
    Steps: lower-casing; removing punctuation, newlines, URLs, usernames, and
    ↪emojis;
    stripping whitespace, replacing hashtags, and finally, lemmatization.

    args:
        tweet: raw text of a tweet

    returns:
        string: cleaned tweet text
    '''

    # Skip retweets and non-strings
    retweet_pattern = r'^RT\s+' # recognize retweets by starting with 'RT'
    if not isinstance(tweet, str) or re.search(retweet_pattern, tweet):
        return ''

    # Convert to lowercase
    tweet = tweet.lower()

```

```

    # Remove punctuation with regex: match all punctuation (\p{P}) and symbols
    ↪(\p{S}),
    # then check that it is not a wasn't a hashtag or @-symbol using a negative
    ↪look-behind.
    # Source: https://github.com/georgetown-mdi/processing-jobs/blob/master/
    ↪pyspark/shared/text_helpers.py
    punc_pattern = r"[\p{P}\p{S}](?https://mathiasbynens.be/demo/
    ↪url-regex
    url_regex = r"https?:\/\/\S*"
    # Regex to match mentions
    mention_regex = r"@S*"
    tweet = re.sub(url_regex, "", tweet)
    tweet = re.sub(mention_regex, "", tweet)

    # Remove additional white spaces
    whitespace_pattern = r'\s+'
    tweet = re.sub(whitespace_pattern, ' ', tweet) # strip whitespaces in
    ↪between words
    tweet = tweet.strip() # strip whitespaces at start & end

    # Replace #word with word
    tweet = re.sub(r'#([\s]+)', r'\1', tweet)

    # Remove emojis
    tweet = emoji.get_emoji_regexp().sub(' ', tweet)

    # Lemmatization
    tweet = tweet.split()
    tweet = ' '.join([stemmer.lemmatize(word) for word in tweet])

    return tweet

msq_df['text_cleaned'] = msq_df['text'].apply(lambda x: process_tweets(x))
fvg_df['text_cleaned'] = fvg_df['text'].apply(lambda x: process_tweets(x))

```

1.3.2 Vectorize texts

```
[7]: # Use TFIDF weighted DTM because does better overall than unweighted
#vectorizer = CountVectorizer(max_features=10000, min_df=1, max_df=0.8,
    ↪stop_words=stopwords.words('english')) # DTM
msq_vectorizer = TfidfVectorizer(max_features=10000, min_df=1, max_df=0.8,
    ↪stop_words=stopwords.words('english')) # TFIDF
fvg_vectorizer = TfidfVectorizer(max_features=10000, min_df=1, max_df=0.8,
    ↪stop_words=stopwords.words('english')) # TFIDF

# creates sparse DTM X
# use X.toarray() to get with zero representation

dis_tweets, rem_tweets, wth_tweets, fvg_tweets, msq_tweets = [], [], [], [], []
    ↪# empty list to add tweets to
msq_df['text_cleaned'].apply(lambda x: msq_tweets.append(x)) # add tweet from
    ↪each row of DF
fvg_df['text_cleaned'].apply(lambda x: fvg_tweets.append(x)) # add tweet from
    ↪each row of DF

X_msq = msq_vectorizer.fit_transform(msq_tweets)
X_fvg = fvg_vectorizer.fit_transform(fvg_tweets)

#save vectorizers
joblib.dump(fvg_vectorizer, open(fvg_vec_fp, "wb"))
joblib.dump(msq_vectorizer, open(msq_vec_fp, "wb"))

print('Number of features in vectorizer (total vocabulary):',
    ↪len(msq_vectorizer.get_feature_names()))
print()

print(msq_vectorizer.get_feature_names()[::100]) # get every 100th word
```

Number of features in vectorizer (total vocabulary): 4624

```
['0206796316', '810', 'agenda21', 'anti', 'awafaucet', 'bill', 'breakthechain',
'catholictwitter', 'class', 'congratulation', 'coronavirustruth', 'crumble',
'democracy', 'distrust', 'eat', 'esg', 'facts', 'flyer', 'generated', 'h1n1',
'highcontainment', 'illness', 'installing', 'kentucky', 'lilo', 'mandate',
'michiganmuniland', 'mudslide', 'nile', 'oracle', 'pensiveface', 'policeman',
'program', 'ra', 'related', 'risky', 'screwed', 'shutdown', 'sort', 'stick',
'surveillance', 'think', 'trending', 'unproven', 'warm',
'womanfacepalmingmediumlightskintone', 'zoom']
```

/home/app59/anaconda3/lib/python3.7/site-

packages/sklearn/utils/deprecation.py:87: FutureWarning: Function

get_feature_names is deprecated; get_feature_names is deprecated in 1.0 and will

be removed in 1.2. Please use `get_feature_names_out` instead.
`warnings.warn(msg, category=FutureWarning)`

1.3.3 Specify the data

```
[ ]: msq_df_is_myth = msq_df[['text_cleaned', 'msq_is_myth']]
     fvg_df_is_myth = fvg_df[['text_cleaned', 'fvg_is_myth']]

msq_df_is_myth_supports = msq_df[['text_cleaned', 'msq_is_myth_supports']].copy()
fvg_df_is_myth_supports = fvg_df[['text_cleaned', 'fvg_is_myth_supports']].copy()
```

1.3.4 Convert No/Yes to [0,1]

```
[9]: def no_yes_convert(convert_df, column_name, has_unsure = False):
     '''
     args
     convert_df: df containing column to convert
     column_name: column to convert from 'yes', 'no', 'unsure' to float.
     ↪ Scoring scheme:
         no: 0
         unsure: 0.5
         yes: 1
     has_unsure: boolean, indicates whether convert_df has 'unsure' in
     ↪ column_name
     '''

     # Already converted to float
     if convert_df[column_name].dtype == 'float64':
         return convert_df

     new_df = convert_df.loc[:, convert_df.columns != column_name]

     for num in range(0, len(new_df)):
         row_index = new_df.index[num]

         if convert_df.loc[num, column_name] == 'no' or convert_df.
         ↪ loc[num, column_name] == 'unsure':
             new_df.loc[row_index, column_name] = 0.0

         elif convert_df.loc[num, column_name] == 'yes':
             new_df.loc[row_index, column_name] = 1.0

     #         elif has_unsure == True and convert_df.loc[num, column_name] ==
     ↪ 'unsure':
     #             new_df.loc[row_index, column_name] = 0.5

     return new_df
```



```
msq_df_is_myth = no_yes_convert(msq_df_is_myth, 'msq_is_myth')
fvg_df_is_myth = no_yes_convert(fvg_df_is_myth, 'fvg_is_myth')
```

1.4 Setup for modeling

1.4.1 Balance x_train, y_train

```
[10]: def resample_data(X_train, Y_train, undersample = False, sampling_ratio = 0.5):
    """
    Args:
        X_train: X training data
        Y_train: Y training data
        undersample: boolean for over or undersampling
        sampling_ratio: ratio of minority to total

    archived/not used:
        sampling_strategy: strategy for resampled distribution
            if oversample: 'majority' makes minority = to majority
            if undersample: 'minority' makes majority = to minority

    Returns:
        X_balanced: predictors at balanced ratio
        Y_balanced: outcomes at balanced ratio
    """

    if undersample == True:
        #TODO: Implement real_sampling_ratio for undersample
        undersample = RandomUnderSampler(sampling_strategy=sampling_ratio)
        X_balanced, Y_balanced = undersample.fit_resample(X_train, Y_train)
    else:
        # real_sampling_ratio is the ratio of the minority to majority, keeping
        ↪majority constant
        real_sampling_ratio = ((sampling_ratio * len(Counter(Y_train)))/
        ↪(1-sampling_ratio))/len(Counter(Y_train))
        oversample = RandomOverSampler(sampling_strategy=real_sampling_ratio)
        X_balanced, Y_balanced = oversample.fit_resample(X_train, Y_train)

    print(f'Y_train: {Counter(Y_train)}\nY_resample: {Counter(Y_balanced)}')

    return X_balanced, Y_balanced
```

```
[11]: def compute_predictions(text, vectorizer_model, class_model):
    """
    Predicts the label for an input text using a given model trained to
    ↪classify the texts.
```

Uses `vectorizer_model` to restrict the vocab of the input text so it's
consistent with vocab in `class_model` (avoids errors).

Args:

`text`: preprocessed text in format of list of sentences, each a str on
list of tokens

`vectorizer_model`: fitted text vectorizer
`class_model`: trained classification model

Returns:

`label`: label for text predicted by model, false for tie
`prob`: probability for label

'''

`X = vectorizer_model.transform(text)` # create TF-IDF-weighted DTM from text

try:

`probabilities = class_model.predict_proba(X)`

except:

`return`

`label = 'no'`

`prob_no = probabilities[0][0]`

`prob_yes = probabilities[0][1]`

predicted label is one with greater probability

if `probabilities[0][0] < probabilities[0][1]`:

`label = 'yes'`

`return label, prob_yes, prob_no`

1.4.2 Setup 10-fold cross validation for model evaluation

```
[12]: # Define test options for k-fold CV
num_folds = 10
seed = 3
scoring='f1_weighted' # set scoring metric (not used here)

def show_kfold_output(models,
                      X,
                      Y,
                      df,
                      text_col,
                      vectorizer,
                      num_folds = num_folds,
                      random_state = seed,
                      shuffle = True):
    '''
```

Estimates the accuracy of different model algorithms, adds results to a `results` array and returns.

Prints the accuracy results: averages and std.

Uses `cross_val_predict`, which unlike `cross_val_score` cannot define scoring option/evaluation metric.

Args:

models: list of (name, model) tuples

X: predictors

Y: outcomes

num_folds: Split data randomly into num_folds parts: (num_folds-1) for training, 1 for scoring

random_state: seed

shuffle:

Returns:

results: list of model results

names: list of model names (matches results)

Source:

<https://stackoverflow.com/questions/40057049/using-confusion-matrix-as-scoring-metric-in-cross-validation-in-scikit-learn>

```
results = []
```

```
names = []
```

```
for name, model in models:
```

```
    # Print name of model
```

```
    print(f'{name}:')
```

```
    print()
```

```
    # Setup model options
```

```
    kfold = KFold(
```

```
        n_splits=num_folds,
```

```
        random_state=seed,
```

```
        shuffle=True)
```

```
    # Get kfold results
```

```
    cv_results = cross_val_predict(
```

```
        model.fit(X, Y),
```

```
        X,
```

```
        Y,
```

```
        cv=kfold,
```

```
        #scoring=scoring,
```

```
        n_jobs=-1) # use all cores = faster
```

```

        # Add results and name of each algorithm to the model array
        results.append(cv_results)
        names.append(name)

        # Validation step: Predict class probabilities in labeled data, compare
        ↪to actual labels
        try:
            tqdm.pandas(desc="Computing predictions")
            df[['prediction', 'prediction_prob_yes', 'prediction_prob_no']] =
            ↪df[text_col].progress_apply(
                lambda text: pd.Series(compute_predictions([sent for sent in
            ↪sent_tokenize(text)], vectorizer, model)))
            print("Distribution of predicted labels:\n", df['prediction'].
            ↪value_counts()) # show predicted distribution, compare to labeled
            ↪distribution
            print()
        except:
            pass

        # Print results
        print(f'Mean (std):\t {round(cv_results.mean(),4)} ({round(cv_results.
        ↪std(),4)})')
        print(f'Accuracy:\t', {round(accuracy_score(Y, cv_results)), 4})
        print()
        print('Confusion matrix:\n', confusion_matrix(Y, cv_results))
        print()
        print('Report:\n', classification_report(Y, cv_results))
        print()

        # Return arrays
        return results, names

```

1.5 Evaluate algorithms: 5G myths

1.5.1 Prepare training and validation data

```

[23]: # Separate training and final validation data set. First remove class
      # label from data (X). Setup target class (Y)
      # Then make the validation set 10% of the entire
      # set of labeled data (X_validate, Y_validate)

valueArray = fvg_df_is_myth.values
Y = valueArray[:,1]
Y = Y.astype('float')
test_size = 0.2
seed = 3
X_train, X_validate, Y_train, Y_validate = train_test_split(

```

```

X_fvg,
Y,
test_size=test_size,
random_state=seed)

print(f'Y_train Distribution: {Counter(Y_train).most_common()}')

```

Y_train Distribution: [(1.0, 466), (0.0, 433)]

```

[24]: #####
# Oversample to desirable ratio
#####

sampling_ratio = 0.5 # ratio of minority to total cases
undersample = False # whether to undersample or oversample

X_balanced, Y_balanced = resample_data(
    X_fvg, #X_train,
    Y, #Y_train,
    undersample=undersample,
    sampling_ratio=sampling_ratio)

```

Y_train: Counter({1.0: 587, 0.0: 537})
Y_resample: Counter({1.0: 587, 0.0: 587})

1.5.2 10-Fold Cross Validation: 5G myths

```

[25]: # Use different algorithms to build models
models = []
models.append(('K-Nearest Neighbors (KNN)', KNeighborsClassifier()))
models.append(('Random Forest (RF)', RandomForestClassifier(n_estimators=40,
    ↪random_state=seed)))
models.append(('Decision Tree (DT)', DecisionTreeClassifier(random_state=seed)))
models.append(('Multinomial Naive Bayes (MNB)', MultinomialNB()))
models.append(('Logistic Regression (LR)',
    ↪LogisticRegression(random_state=seed)))
models.append(('Support Vector Machine (SVM)', SVC(gamma='auto')))
models.append(('Multi-Layer Perceptron (MLP)', MLPClassifier(max_iter=100,
    ↪activation='relu')))

# vectorizer = TfidfVectorizer(max_features=10000, min_df=1, max_df=0.8,
    ↪stop_words=stopwords.words('english')) # TFIDF Vectorizer
# vectorizer.fit(fvg_tweets)

# Baseline: distribution of labeled data
print(f'Distribution of labeled disinfectants tweets: {Counter(Y_balanced).
    ↪most_common()}')

```

```

print()

# Evaluate algorithms using 10-fold cross validation
results, names = show_kfold_output(models=models,
                                   X=X_balanced,
                                   Y=Y_balanced,
                                   df=fvg_df,
                                   text_col='text_cleaned',
                                   vectorizer=fvg_vectorizer)

```

Distribution of labeled disinfectants tweets: [(1.0, 587), (0.0, 587)]

K-Nearest Neighbors (KNN):

Computing predictions: 100%| | 1124/1124 [00:02<00:00, 434.41it/s]

Distribution of predicted labels:

yes 661

no 463

Name: prediction, dtype: int64

Mean (std): 0.5971 (0.4905)

Accuracy: {1.0, 4}

Confusion matrix:

[[449 138]

[24 563]]

Report:

	precision	recall	f1-score	support
0.0	0.95	0.76	0.85	587
1.0	0.80	0.96	0.87	587
accuracy			0.86	1174
macro avg	0.88	0.86	0.86	1174
weighted avg	0.88	0.86	0.86	1174

Random Forest (RF):

Computing predictions: 100%| | 1124/1124 [00:07<00:00, 153.13it/s]

Distribution of predicted labels:

yes 587

no 537

Name: prediction, dtype: int64

Mean (std): 0.5085 (0.4999)
Accuracy: {1.0, 4}

Confusion matrix:
[[559 28]
[18 569]]

Report:

	precision	recall	f1-score	support
0.0	0.97	0.95	0.96	587
1.0	0.95	0.97	0.96	587
accuracy			0.96	1174
macro avg	0.96	0.96	0.96	1174
weighted avg	0.96	0.96	0.96	1174

Decision Tree (DT):

Computing predictions: 100%| | 1124/1124 [00:01<00:00, 622.66it/s]
Computing predictions: 7%| | 79/1124 [00:00<00:01, 785.30it/s]

Distribution of predicted labels:

yes 587

no 537

Name: prediction, dtype: int64

Mean (std): 0.5009 (0.5)
Accuracy: {1.0, 4}

Confusion matrix:
[[561 26]
[25 562]]

Report:

	precision	recall	f1-score	support
0.0	0.96	0.96	0.96	587
1.0	0.96	0.96	0.96	587
accuracy			0.96	1174
macro avg	0.96	0.96	0.96	1174
weighted avg	0.96	0.96	0.96	1174

Multinomial Naive Bayes (MNB):

```
Computing predictions: 100%|          | 1124/1124 [00:01<00:00, 693.94it/s]
Computing predictions:  0%|          | 0/1124 [00:00<?, ?it/s]
```

Distribution of predicted labels:

yes 607

no 517

Name: prediction, dtype: int64

Mean (std): 0.5426 (0.4982)

Accuracy: {1.0, 4}

Confusion matrix:

```
[[517  70]
```

```
[ 20 567]]
```

Report:

	precision	recall	f1-score	support
0.0	0.96	0.88	0.92	587
1.0	0.89	0.97	0.93	587
accuracy			0.92	1174
macro avg	0.93	0.92	0.92	1174
weighted avg	0.93	0.92	0.92	1174

Logistic Regression (LR):

```
Computing predictions: 100%|          | 1124/1124 [00:01<00:00, 767.05it/s]
```

Distribution of predicted labels:

yes 594

no 530

Name: prediction, dtype: int64

Mean (std): 0.4872 (0.4998)

Accuracy: {1.0, 4}

Confusion matrix:

```
[[559  28]
```

```
[ 43 544]]
```

Report:

	precision	recall	f1-score	support
0.0	0.93	0.95	0.94	587
1.0	0.95	0.93	0.94	587

accuracy			0.94	1174
macro avg	0.94	0.94	0.94	1174
weighted avg	0.94	0.94	0.94	1174

Support Vector Machine (SVM):

```
Computing predictions:  0%|          | 0/1124 [00:00<?,
?it/s]/home/app59/anaconda3/lib/python3.7/site-
packages/ipykernel_launcher.py:71: DeprecationWarning: The default dtype for
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Computing predictions: 13%| | 141/1124 [00:00<00:01, 706.71it/s]

/home/app59/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:71: DeprecationWarning: The default dtype for empty Series will be 'object' instead of 'float64' in a future version. Specify a dtype explicitly to silence this warning.

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Computing predictions: 19%|          | 212/1124 [00:00<00:01,
706.87it/s]/home/app59/anaconda3/lib/python3.7/site-
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```

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Computing predictions: 25%|          | 281/1124 [00:00<00:01,
700.82it/s]/home/app59/anaconda3/lib/python3.7/site-
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```


[illegible]


```

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Computing predictions: 31%|          | 350/1124 [00:00<00:01,
694.64it/s]/home/app59/anaconda3/lib/python3.7/site-
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Computing predictions: 37%|          | 414/1124 [00:00<00:01,
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Computing predictions:  43%|          | 478/1124 [00:00<00:00,
662.96it/s]/home/app59/anaconda3/lib/python3.7/site-
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Computing predictions: 48%|          | 542/1124 [00:00<00:00,
654.48it/s]/home/app59/anaconda3/lib/python3.7/site-
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Computing predictions:  54%|          | 611/1124 [00:00<00:00,
664.40it/s]/home/app59/anaconda3/lib/python3.7/site-
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Computing predictions: 60%| | 675/1124 [00:01<00:00, 653.38it/s]/home/app59/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:71: DeprecationWarning: The default dtype for empty Series will be 'object' instead of 'float64' in a future version. Specify a dtype explicitly to silence this warning.

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DeprecationWarning: The default dtype for empty Series will be 'object' instead
of 'float64' in a future version. Specify a dtype explicitly to silence this
warning.
Computing predictions: 66%|          | 744/1124 [00:01<00:00,
662.81it/s]/home/app59/anaconda3/lib/python3.7/site-
packages/ipykernel_launcher.py:71: DeprecationWarning: The default dtype for
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DeprecationWarning: The default dtype for empty Series will be 'object' instead
of 'float64' in a future version. Specify a dtype explicitly to silence this
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Computing predictions: 72%|          | 813/1124 [00:01<00:00,
669.63it/s]/home/app59/anaconda3/lib/python3.7/site-
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DeprecationWarning: The default dtype for empty Series will be 'object' instead
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Computing predictions: 78%|          | 880/1124 [00:01<00:00,
654.08it/s]/home/app59/anaconda3/lib/python3.7/site-
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DeprecationWarning: The default dtype for empty Series will be 'object' instead of 'float64' in a future version. Specify a dtype explicitly to silence this warning.

Computing predictions: 84%| | 945/1124 [00:01<00:00, 648.40it/s]

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DeprecationWarning: The default dtype for empty Series will be 'object' instead
of 'float64' in a future version. Specify a dtype explicitly to silence this
warning.
Computing predictions: 90%|          | 1010/1124 [00:01<00:00,
642.26it/s]/home/app59/anaconda3/lib/python3.7/site-
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```

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DeprecationWarning: The default dtype for empty Series will be 'object' instead
of 'float64' in a future version. Specify a dtype explicitly to silence this
warning.
Computing predictions: 96%|          | 1078/1124 [00:01<00:00,
650.71it/s]/home/app59/anaconda3/lib/python3.7/site-
packages/ipykernel_launcher.py:71: DeprecationWarning: The default dtype for
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```
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DeprecationWarning: The default dtype for empty Series will be 'object' instead of 'float64' in a future version. Specify a dtype explicitly to silence this warning.
Computing predictions: 100%| | 1124/1124 [00:01<00:00, 616.44it/s]
Mean (std): 0.5997 (0.49)
Accuracy: {0.0, 4}

Confusion matrix:

```
[[220 367]
 [250 337]]
```

Report:

	precision	recall	f1-score	support
0.0	0.47	0.37	0.42	587
1.0	0.48	0.57	0.52	587
accuracy			0.47	1174
macro avg	0.47	0.47	0.47	1174
weighted avg	0.47	0.47	0.47	1174

Multi-Layer Perceptron (MLP):

Computing predictions: 100%| | 1124/1124 [00:01<00:00, 744.83it/s]

Distribution of predicted labels:

```
yes    587
no     537
```

Name: prediction, dtype: int64

Mean (std): 0.4974 (0.5)
Accuracy: {1.0, 4}

Confusion matrix:

```
[[544  43]
 [ 46 541]]
```

Report:

	precision	recall	f1-score	support
--	-----------	--------	----------	---------

0.0	0.92	0.93	0.92	587
1.0	0.93	0.92	0.92	587
accuracy			0.92	1174
macro avg	0.92	0.92	0.92	1174
weighted avg	0.92	0.92	0.92	1174

```
[26]: # Save best model - 5G

# Model file output format
best_model_suffix = "LR" # this model has best accuracy
thisday = date.today().strftime("%m%d%y")

MYTH_NAME_mod_fp = f'../models/
↳tweet_classifier_5G_{str(best_model_suffix)}_{str(thisday)}.joblib'

best_model = LogisticRegression(random_state=seed).fit(X_train, Y_train)

joblib.dump(best_model, MYTH_NAME_mod_fp)
```

```
[26]: ['../models/tweet_classifier_5G_LR_042622.joblib']
```

1.5.3 Inspect featured keywords (Random Forest)

```
[27]: # Get feature names
# feature_names = [f"feature {i}" for i in range(X_balanced.shape[1])]
feature_names = fvg_vectorizer.get_feature_names_out()
rf_model = RandomForestClassifier(n_estimators=40, random_state=seed).
↳fit(X_balanced, Y_balanced)

# Get feature importances from the random forest model
importances = rf_model.feature_importances_
std = np.std(
    [tree.feature_importances_ for tree in rf_model.estimators_], axis=0)

print(type(feature_names))
print(type(X_balanced))

print(X_balanced.shape)
print(feature_names.shape)

# Build dataframe
forest_importances = pd.DataFrame()
forest_importances["importances"] = importances
```



```

forest_importances["std"] = std
forest_importances.index = feature_names
forest_importances = forest_importances.sort_values(
    by=["importances", "std"], ascending=False)

# See top k important features
top_k = 10
top_k_forest_importances = forest_importances.head(top_k)
print(list(top_k_forest_importances.index))

```

```

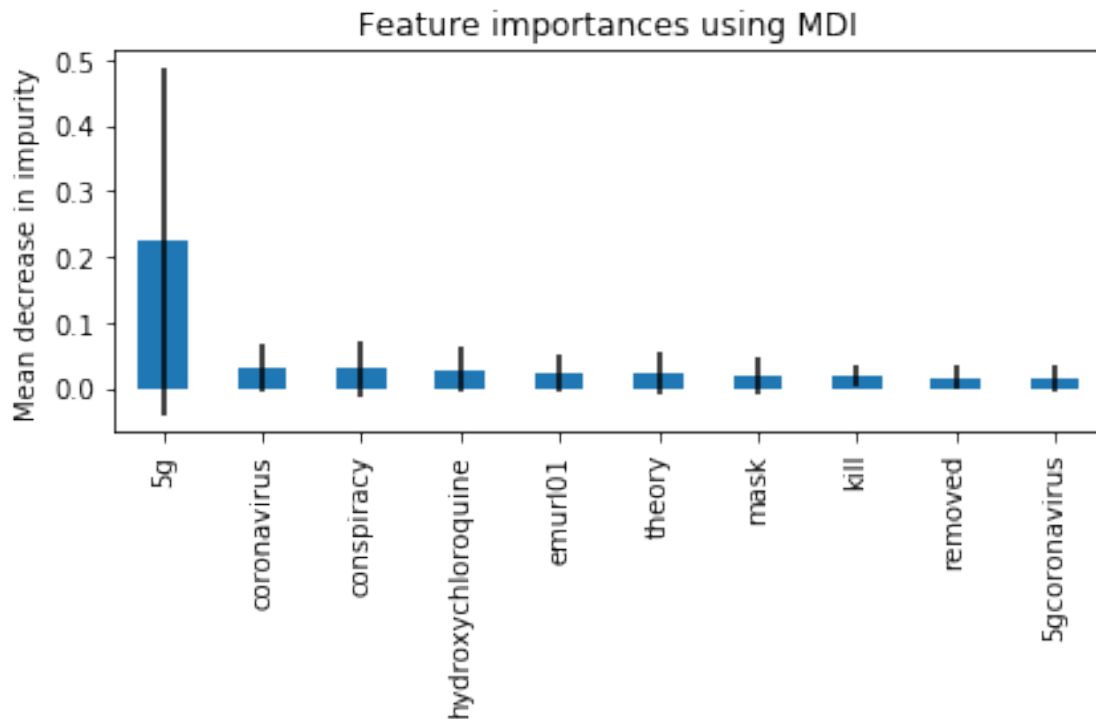
<class 'numpy.ndarray'>
<class 'scipy.sparse.csr.csr_matrix'>
(1174, 5086)
(5086,)
['5g', 'coronavirus', 'conspiracy', 'hydroxychloroquine', 'emurl01', 'theory',
'mask', 'kill', 'removed', '5gcoronavirus']

```

```

[28]: fig, ax = plt.subplots()
top_k_forest_importances["importances"].plot.bar(
    yerr=top_k_forest_importances["std"], ax=ax)
ax.set_title("Feature importances")
ax.set_ylabel("Mean decrease in impurity")
fig.tight_layout()

```



1.6 Evaluate Algorithms: Mosquito myth

1.6.1 Prepare training and validation data

```
[29]: # Separate training and final validation data set. First remove class
# label from data (X). Setup target class (Y)
# Then make the validation set 10% of the entire
# set of labeled data (X_validate, Y_validate)

valueArray = msq_df_is_myth.values
Y = valueArray[:,1]
Y = Y.astype('float')
test_size = 0.2
seed = 3
X_train, X_validate, Y_train, Y_validate = train_test_split(
    X_msq,
    Y,
    test_size=test_size,
    random_state=seed)

print(f'Y_train Distribution: {Counter(Y_train).most_common()}')
```

```
Y_train Distribution: [(0.0, 557), (1.0, 441)]
```

1.6.2 Oversample to desirable ratio

```
[30]: sampling_ratio = 0.5 # ratio of minority to total cases
undersample = False # whether to undersample or oversample

X_balanced, Y_balanced = resample_data(
    X_msq, #X_train,
    Y, #Y_train,
    undersample=undersample,
    sampling_ratio=sampling_ratio)
```

```
Y_train: Counter({0.0: 685, 1.0: 563})
Y_resample: Counter({1.0: 685, 0.0: 685})
```

1.7 10-Fold Cross Validation: Mosquito myth

```
[31]: models = []
models.append(('K-Nearest Neighbors (KNN)', KNeighborsClassifier()))
models.append(('Random Forest (RF)', RandomForestClassifier(n_estimators=40,
    ↪random_state=seed)))
models.append(('Decision Tree (DT)', DecisionTreeClassifier(random_state=seed)))
models.append(('Multinomial Naive Bayes (MNB)', MultinomialNB()))
models.append(('Logistic Regression (LR)',
    ↪LogisticRegression(random_state=seed)))
```

```

models.append(('Support Vector Machine (SVM)', SVC(gamma='auto')))
models.append(('Multi-Layer Perceptron (MLP)', MLPClassifier(max_iter=100,
↳activation='relu')))

# Baseline: distribution of labeled data
print(f'Distribution of labeled disinfectants tweets: {Counter(Y_balanced).
↳most_common()}'')
print()

# Evaluate algorithms using 10-fold cross validation
results, names = show_kfold_output(models=models,
                                   X=X_balanced,
                                   Y=Y_balanced,
                                   df=msq_df,
                                   text_col='text_cleaned',
                                   vectorizer=msq_vectorizer)

```

Computing predictions: 0%| | 0/1248 [00:00<?, ?it/s]

Distribution of labeled disinfectants tweets: [(1.0, 685), (0.0, 685)]

K-Nearest Neighbors (KNN):

Computing predictions: 100%| | 1248/1248 [00:02<00:00, 453.66it/s]

Distribution of predicted labels:

yes 732

no 516

Name: prediction, dtype: int64

Mean (std): 0.6672 (0.4712)

Accuracy: {1.0, 4}

Confusion matrix:

[[436 249]

[20 665]]

Report:

	precision	recall	f1-score	support
0.0	0.96	0.64	0.76	685
1.0	0.73	0.97	0.83	685
accuracy			0.80	1370
macro avg	0.84	0.80	0.80	1370
weighted avg	0.84	0.80	0.80	1370

Random Forest (RF):

Computing predictions: 100%| | 1248/1248 [00:08<00:00, 153.51it/s]

Distribution of predicted labels:

no 676

yes 572

Name: prediction, dtype: int64

Mean (std): 0.5241 (0.4994)

Accuracy: {1.0, 4}

Confusion matrix:

[[640 45]

[12 673]]

Report:

	precision	recall	f1-score	support
0.0	0.98	0.93	0.96	685
1.0	0.94	0.98	0.96	685
accuracy			0.96	1370
macro avg	0.96	0.96	0.96	1370
weighted avg	0.96	0.96	0.96	1370

Decision Tree (DT):

Computing predictions: 100%| | 1248/1248 [00:01<00:00, 642.24it/s]

Computing predictions: 6%| | 77/1248 [00:00<00:01, 766.29it/s]

Distribution of predicted labels:

no 684

yes 564

Name: prediction, dtype: int64

Mean (std): 0.519 (0.4996)

Accuracy: {1.0, 4}

Confusion matrix:

[[641 44]

[18 667]]

Report:

	precision	recall	f1-score	support
0.0	0.97	0.94	0.95	685

	1.0	0.94	0.97	0.96	685
accuracy				0.95	1370
macro avg	0.96	0.95	0.95	0.95	1370
weighted avg	0.96	0.95	0.95	0.95	1370

Multinomial Naive Bayes (MNB):

Computing predictions: 100%| | 1248/1248 [00:01<00:00, 727.79it/s]
Computing predictions: 0%| | 0/1248 [00:00<?, ?it/s]

Distribution of predicted labels:

yes 639
no 609

Name: prediction, dtype: int64

Mean (std): 0.646 (0.4782)
Accuracy: {1.0, 4}

Confusion matrix:

```
[[480 205]
 [ 5 680]]
```

Report:

	precision	recall	f1-score	support
0.0	0.99	0.70	0.82	685
1.0	0.77	0.99	0.87	685
accuracy			0.85	1370
macro avg	0.88	0.85	0.84	1370
weighted avg	0.88	0.85	0.84	1370

Logistic Regression (LR):

Computing predictions: 100%| | 1248/1248 [00:01<00:00, 756.28it/s]

Distribution of predicted labels:

no 666
yes 582

Name: prediction, dtype: int64

Mean (std): 0.5073 (0.4999)
Accuracy: {1.0, 4}

Confusion matrix:

```
[[644 41]
 [ 31 654]]
```

Report:

	precision	recall	f1-score	support
0.0	0.95	0.94	0.95	685
1.0	0.94	0.95	0.95	685
accuracy			0.95	1370
macro avg	0.95	0.95	0.95	1370
weighted avg	0.95	0.95	0.95	1370

Support Vector Machine (SVM):

```
Computing predictions: 0%|          | 0/1248 [00:00<?,
?it/s]/home/app59/anaconda3/lib/python3.7/site-
packages/ipykernel_launcher.py:71: DeprecationWarning: The default dtype for
empty Series will be 'object' instead of 'float64' in a future version. Specify
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```



```
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/home/app59/anaconda3/lib/python3.7/site-packages/ipynotebook_launcher.py:71:  
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```


[illegible]

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Computing predictions: 5%| | 67/1248 [00:00<00:01, 669.08it/s]

/home/app59/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:71: DeprecationWarning: The default dtype for empty Series will be 'object' instead of 'float64' in a future version. Specify a dtype explicitly to silence this warning.

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Computing predictions: 11%| | 139/1248 [00:00<00:01, 682.36it/s]

/home/app59/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:71: DeprecationWarning: The default dtype for empty Series will be 'object' instead of 'float64' in a future version. Specify a dtype explicitly to silence this warning.

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DeprecationWarning: The default dtype for empty Series will be 'object' instead
of 'float64' in a future version. Specify a dtype explicitly to silence this
warning.
Computing predictions: 17%|          | 208/1248 [00:00<00:01,
684.24it/s]/home/app59/anaconda3/lib/python3.7/site-
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DeprecationWarning: The default dtype for empty Series will be 'object' instead
of 'float64' in a future version. Specify a dtype explicitly to silence this
warning.
Computing predictions: 22%|          | 275/1248 [00:00<00:01,
677.34it/s]/home/app59/anaconda3/lib/python3.7/site-
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DeprecationWarning: The default dtype for empty Series will be 'object' instead
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Computing predictions: 27%|          | 337/1248 [00:00<00:01,
658.53it/s]/home/app59/anaconda3/lib/python3.7/site-
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Computing predictions: 32%| | 403/1248 [00:00<00:01,

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656.91it/s]/home/app59/anaconda3/lib/python3.7/site-
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Computing predictions: 37%|          | 465/1248 [00:00<00:01,
644.88it/s]/home/app59/anaconda3/lib/python3.7/site-
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DeprecationWarning: The default dtype for empty Series will be 'object' instead
of 'float64' in a future version. Specify a dtype explicitly to silence this
warning.
Computing predictions: 42%|          | 530/1248 [00:00<00:01,
644.74it/s]/home/app59/anaconda3/lib/python3.7/site-
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Computing predictions: 48%| | 593/1248 [00:00<00:01, 638.35it/s]/home/app59/anaconda3/lib/python3.7/site-packages/ipykernel_launcher.py:71: DeprecationWarning: The default dtype for empty Series will be 'object' instead of 'float64' in a future version. Specify a dtype explicitly to silence this warning.

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Computing predictions:  58%|          | 718/1248 [00:01<00:00,
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DeprecationWarning: The default dtype for empty Series will be 'object' instead
of 'float64' in a future version. Specify a dtype explicitly to silence this
warning.
Computing predictions: 63%|          | 781/1248 [00:01<00:00,
626.36it/s]/home/app59/anaconda3/lib/python3.7/site-
packages/ipykernel_launcher.py:71: DeprecationWarning: The default dtype for
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[illegible]

[illegible]

[illegible]

[illegible]

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of 'float64' in a future version. Specify a dtype explicitly to silence this warning.  
Computing predictions:   68%|          | 846/1248 [00:01<00:00,  
633.07it/s]/home/app59/anaconda3/lib/python3.7/site-  
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DeprecationWarning: The default dtype for empty Series will be 'object' instead
of 'float64' in a future version. Specify a dtype explicitly to silence this
warning.
Computing predictions: 73%|          | 909/1248 [00:01<00:00,
615.82it/s]/home/app59/anaconda3/lib/python3.7/site-
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DeprecationWarning: The default dtype for empty Series will be 'object' instead
of 'float64' in a future version. Specify a dtype explicitly to silence this
warning.
Computing predictions: 78%|          | 974/1248 [00:01<00:00,
623.66it/s]/home/app59/anaconda3/lib/python3.7/site-
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DeprecationWarning: The default dtype for empty Series will be 'object' instead
of 'float64' in a future version. Specify a dtype explicitly to silence this
warning.
Computing predictions: 83%|          | 1042/1248 [00:01<00:00,
637.50it/s]/home/app59/anaconda3/lib/python3.7/site-
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```

[illegible]

[illegible]

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```

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Computing predictions: 89%|          | 1106/1248 [00:01<00:00,
630.55it/s]/home/app59/anaconda3/lib/python3.7/site-
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of 'float64' in a future version. Specify a dtype explicitly to silence this
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Computing predictions: 94%|          | 1176/1248 [00:01<00:00,
648.82it/s]/home/app59/anaconda3/lib/python3.7/site-
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warning.
Computing predictions: 99%|          | 1241/1248 [00:01<00:00,
638.21it/s]/home/app59/anaconda3/lib/python3.7/site-
packages/ipykernel_launcher.py:71: DeprecationWarning: The default dtype for
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of 'float64' in a future version. Specify a dtype explicitly to silence this
warning.
Computing predictions: 100%|         | 1248/1248 [00:02<00:00, 599.00it/s]

Mean (std):      0.4 (0.4899)
Accuracy:        {0.0, 4}

Confusion matrix:
[[389 296]
 [433 252]]

Report:
precision    recall  f1-score   support

```

	0.0	0.47	0.57	0.52	685
	1.0	0.46	0.37	0.41	685
accuracy				0.47	1370
macro avg		0.47	0.47	0.46	1370
weighted avg		0.47	0.47	0.46	1370

Multi-Layer Perceptron (MLP):

```
/home/app59/anaconda3/lib/python3.7/site-
packages/sklearn/neural_network/_multilayer_perceptron.py:696:
ConvergenceWarning: Stochastic Optimizer: Maximum iterations (100) reached and
the optimization hasn't converged yet.
```

```
ConvergenceWarning,
Computing predictions: 100%|          | 1248/1248 [00:01<00:00, 727.00it/s]
```

Distribution of predicted labels:

```
no      683
```

```
yes     565
```

```
Name: prediction, dtype: int64
```

```
Mean (std):      0.4905 (0.4999)
```

```
Accuracy:        {1.0, 4}
```

Confusion matrix:

```
[[644  41]
```

```
 [ 54 631]]
```

Report:

	precision	recall	f1-score	support
0.0	0.92	0.94	0.93	685
1.0	0.94	0.92	0.93	685
accuracy			0.93	1370
macro avg	0.93	0.93	0.93	1370
weighted avg	0.93	0.93	0.93	1370

```
[32]: # Save best model - Mosquitoes

#Model file output format
best_model_suffix = "LR" # this model has best accuracy
```

```

thisday = date.today().strftime("%m%d%y")

MYTH_NAME_mod_fp = f'../models/
    ↳tweet_classifier_mosquitoes_{str(best_model_suffix)}_{str(thisday)}.joblib'

best_model = LogisticRegression(random_state=seed).fit(X_balanced, Y_balanced)

joblib.dump(best_model, MYTH_NAME_mod_fp)

```

[32]: ['../models/tweet_classifier_mosquitoes_LR_042622.joblib']

1.7.1 Inspect featured keywords (Random Forest)

```

[33]: # Get feature names
# feature_names = [f"feature {i}" for i in range(X_balanced.shape[1])]
feature_names = msq_vectorizer.get_feature_names_out()
rf_model = RandomForestClassifier(n_estimators=40, random_state=seed).
    ↳fit(X_balanced, Y_balanced)

# Get feature importances from the random forest model
importances = rf_model.feature_importances_
std = np.std(
    [tree.feature_importances_ for tree in rf_model.estimators_], axis=0)

print(type(feature_names))
print(type(X_balanced))

print(X_balanced.shape)
print(feature_names.shape)

# Build dataframe
forest_importances = pd.DataFrame()
forest_importances["importances"] = importances
forest_importances["std"] = std
forest_importances.index = feature_names
forest_importances = forest_importances.sort_values(
    by=["importances", "std"], ascending=False)

# See top k important features
top_k = 10
top_k_forest_importances = forest_importances.head(top_k)
print(list(top_k_forest_importances.index))

```

```

<class 'numpy.ndarray'>
<class 'scipy.sparse.csr.csr_matrix'>
(1370, 4624)
(4624,)

```



```
['mosquito', 'transmitted', 'coronavirus', 'covid19', 'bite', 'removed',  
'transmit', 'carry', 'emurl01', 'em']
```

```
[34]: fig, ax = plt.subplots()  
      top_k_forest_importances["importances"].plot.bar(  
          yerr=top_k_forest_importances["std"], ax=ax)  
      ax.set_title("Feature importances")  
      ax.set_ylabel("Mean decrease in impurity")  
      fig.tight_layout()
```

