k-fold cross validation and logistic regression

In [ ]:
```
import os
import pandas as pd
import numpy as np
from tqdm import tqdm
import matplotlib.pyplot as plt
import sklearn
from sklearn.model_selection import KFold
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score, log_loss,confusion_matrix

import sys
sys.path.append('../')
sys.path.append('../preprocess')

import preprocess
from preprocess.LiarLiarPreProcessor import LiarLiarPreProcessor
```

merge train and validation data for CV

In [ ]:
```
def concat_train_valid_set(datafolder):
    # read the two TSV files
    df1 = pd.read_csv(os.path.join(datafolder,'train.tsv'), sep='\t')
    df2 = pd.read_csv(os.path.join(datafolder,'valid.tsv'), sep='\t')


    columns = [
            'id',                # Column 1: the ID of the statement ([ID].jso
            'label',             # Column 2: the label.
            'statement',         # Column 3: the statement.
            'subjects',          # Column 4: the subject(s).
            'speaker',           # Column 5: the speaker.
            'speaker_job_title', # Column 6: the speaker's job title.
            'state_info',        # Column 7: the state info.
            'party_affiliation', # Column 8: the party affiliation.

            # Column 9-13: the total credit history count, including the curre
            'count_1', # barely true counts.
            'count_2', # false counts.
            'count_3', # half true counts.
            'count_4', # mostly true counts.
            'count_5', # pants on fire counts.

            'context' # Column 14: the context (venue / location of the speech
        ]

    df1.columns = columns
    df2.columns = columns
    # merge the two dataframes on a common column
    merged_df = pd.concat([df1, df2], ignore_index=True)


    merged_df.to_csv(os.path.join(datafolder,'train_valid.tsv'),
                     sep='\t', index=False)

    return merged_df
```

In [ ]:
```
root_folder = os.path.dirname(os.getcwd())
datafolder = os.path.join(root_folder,'datasets')
merged_df = concat_train_valid_set(datafolder)
```

Import data and use LiarLiarPreprocessor to process raw textual data

In [ ]:
```
liar_liar_pre_processor = LiarLiarPreProcessor(verbose=False)

#load the training data
liar_liar_pre_processor.import_training_data(
    file_name="train.tsv",
    deliminator='\t',
    custom_headers=None,
    replace_Null_NaN=True
)

#set the label column
liar_liar_pre_processor.set_label_header(
    label_header='label',
    custom_label_encoding=False,
    normalize=False,
    binarize=True
)
encoder_parameters = [
    {"encoder_name": "statement",
        "encoder_type":"bag-of-words",
        "feature_name":"statement",
        "clean_strings":True,
        "remove_stop_words":True,
        "lematize":True,
        "filtering" : {
            "filtering_enabled":False,
            "filtered_terms": []
        }
    },
    {"encoder_name": "party affiliation",
        "encoder_type":"encode",
        "feature_name":"party_affiliation",
        "encoding_mapping":None,
        "normalize":False,
        "Binarize":False,
        "filtering" : {
            "filtering_enabled":True,
            "filtered_terms": ['republican', 'democrat', 'none']
        }
    },
    {"encoder_name": "credit score",
        "encoder_type":"credit history",
        "feature_names":['count_1','count_2','count_3','count_4','count_5'],
        "compute_credit_history":True
    },

    {"encoder_name": "state info",
        "encoder_type":"encode",
        "feature_name":"state_info",
        "encoding_mapping":None,
        "normalize":False,
        "Binarize":False,
```

```
        "filtering" : {
            "filtering_enabled":False,
            "filtered_terms": []
        }
    },
    {"encoder_name": "speaker",
        "encoder_type":"encode",
        "feature_name":"speaker",
        "clean_strings":True,
        "remove_stop_words":True,
        "lematize":True,
        "filtering" : {
            "filtering_enabled":False,
            "filtered_terms": []
        }
    },
    {"encoder_name": "speaker_job_title",
        "encoder_type":"encode",
        "feature_name":"speaker_job_title",
        "clean_strings":True,
        "remove_stop_words":True,
        "lematize":True,
        "filtering" : {
            "filtering_enabled":False,
            "filtered_terms": []
        }
    },
    {"encoder_name": "subject",
        "encoder_type":"bag-of-words",
        "feature_name":"subjects",
        "clean_strings":True,
        "remove_stop_words":True,
        "lematize":True,
        "filtering" : {
            "filtering_enabled":False,
            "filtered_terms": []
        }
    }
]
```

In [ ]:
```
#load the encoding configurations for the desired dataset
liar_liar_pre_processor.configure_encodings(encoder_parameters=encoder_paramet
# apply encoding
y,X0,X_headers0 = liar_liar_pre_processor.get_dataset()
```

```
/home/david/Documents/sta561project/modeling_logistic/../preprocess/Encoder.p
y:330: RuntimeWarning: invalid value encountered in true_divide
  weighted_credit_counts = credit_counts / sums[:,None]
```

In [ ]:
```
y_test,X_test0 = liar_liar_pre_processor.apply_encodings_to_new_data('test.tsv
```

```
/home/david/Documents/sta561project/modeling_logistic/../preprocess/Encoder.p
y:330: RuntimeWarning: invalid value encountered in true_divide
  weighted_credit_counts = credit_counts / sums[:,None]
```

for each input feature condition, lasso logistic CV

In [ ]:
```
def getXByfeatureOption(input_features, X0, X_headers0, Xtest0=None):
    metadata_col_start_idx = X_headers0.index('party affiliation')
```

```
    if input_features == 'statements':
        X = X0[:,:metadata_col_start_idx]
        X_headers = X_headers0[:metadata_col_start_idx]
        if Xtest0 is not None :
            Xtest = Xtest0[:,:metadata_col_start_idx]
    elif input_features == 'metadata':
        X = X0[:,metadata_col_start_idx:]
        X_headers = X_headers0[metadata_col_start_idx:]
        if Xtest0 is not None :
            Xtest = Xtest0[:,metadata_col_start_idx:]
    elif input_features == 'both':
        X =X0
        X_headers = X_headers0
        if Xtest0 is not None :
            Xtest = Xtest0
    else:
        raise ValueError(f'input features option {input_features} not implemen
    if Xtest0 is not None:
        return X, X_headers,Xtest
    else:
        return X, X_headers
```

In [ ]:

```
def lasso_CV (X,y,n_fold,
              Cs = np.logspace(-4, 4, 9),
              random_state = 42):

    # perform k-fold cross-validation for Lasso logistic regression

    kf = KFold(n_splits=n_fold,shuffle=True, random_state=random_state)
    lasso_cv_accuracy_scores = np.zeros((len(Cs),n_fold))
    lasso_cv_loss_scores = np.zeros((len(Cs),n_fold))
    for i_C,C in enumerate(tqdm(Cs)):
        cv_accuracy_scores = []
        cv_loss_scores = []
        for i_fold,(train_index,val_index)in enumerate(kf.split(X)):
            if random_state:
                fold_seed = random_state*(i_C+1)*(i_fold+1)
                lasso = LogisticRegression(penalty='l1',
                                           C=C,
                                           solver='saga',
                                           random_state=fold_seed)
            else:
                lasso = LogisticRegression(penalty='l1', C=C, solver='saga')
            X_train,y_train = X[train_index],y[train_index]
            X_val,y_val = X[val_index],y[val_index]
            lasso.fit(X_train, y_train.flatten())
            y_pred = lasso.predict(X_val).flatten()
            cv_accuracy_scores.append(accuracy_score(y_val, y_pred))
            cv_loss_scores.append(log_loss(y_val, y_pred))
        lasso_cv_accuracy_scores[i_C,:] = cv_accuracy_scores
        lasso_cv_loss_scores[i_C,:] = cv_loss_scores
    return lasso_cv_accuracy_scores, lasso_cv_loss_scores


def summarize_performance(Cs,n_fold,lasso_cv_acc_scores,lasso_cv_loss_scores):
    df_cv_score = pd.DataFrame({'C': np.repeat(Cs,n_fold),
                                'accuracy':lasso_cv_acc_scores.flatten(),
                                'log_loss':lasso_cv_loss_scores.flatten()})
```

```
    df_cv_score_agg = df_cv_score.groupby('C').agg({'accuracy':[np.mean,np.std
                                'log_loss':[np.mean,np.std]})
    df_cv_score_agg.columns = ['{}_{}'.format(col[0], col[1]) for col in df_cv
    df_cv_score_agg = df_cv_score_agg.reset_index()


    return df_cv_score_agg


def plot_performance_df (df_cv_score_agg,input_features):
    fig,ax = plt.subplots(1,2,figsize=(10,4))
    ax[0] = df_cv_score_agg.plot(kind='line',
                                 x='C',
                                 ax = ax[0],
                                 y='accuracy_mean',
                                 yerr ='accuracy_std',
                                 label='accuracy')
    ax[0].set_xscale('log')
    ax[0].set_ylabel('accuracy')
    ax[0].set_xlabel('l1 penalty')

    ax[1] = df_cv_score_agg.plot(kind='line',
                                 x='C',
                                 ax = ax[1],
                                 y='log_loss_mean',
                                 yerr ='log_loss_std',
                                 label='log loss')
    ax[1].set_xscale('log')
    ax[1].set_ylabel('log loss')
    ax[1].set_xlabel('l1 penalty')

    fig.suptitle(f"""input = {input_features},
             max accuracy = {df_cv_score_agg['accuracy_mean'].max():.3f} with

    plt.close(fig)
    return fig
```

Using different input feature: statement, or metadata or both, fit logistic regression

In [ ]:
```
performance_df_dict = {}
performance_fig_dict = {}
random_state =42
Cs = np.logspace(-4, 4, 9)
n_fold = 5
```

In [ ]:
```
input_features = 'statements'
X, X_headers = getXByfeatureOption(input_features, X0, X_headers0)

lasso_cv_acc_scores, lasso_cv_loss_scores = lasso_CV(X[::],
                                                     y[::],
                                                     n_fold = n_fold,
                                                     Cs = Cs,
                                                    random_state = random_stat
df_cv_score_agg = summarize_performance(Cs,n_fold,lasso_cv_acc_scores,lasso_cv
fig = plot_performance_df(df_cv_score_agg,input_features)

performance_df_dict[input_features] = df_cv_score_agg
```

```
performance_fig_dict[input_features] = fig
fig
```

```
 33%|███       | 3/9 [00:47<01:57, 19.60s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
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y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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 44%|████      | 4/9 [04:19<07:57, 95.42s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
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  warnings.warn(
 56%|█████     | 5/9 [09:27<11:28, 172.13s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
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y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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  warnings.warn(
```

```
 67%|██████    | 6/9 [15:27<11:47, 235.97s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
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y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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 78%|███████▊  | 7/9 [21:30<09:15, 277.58s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
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y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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  warnings.warn(
 89%|████████▉ | 8/9 [27:35<05:05, 305.53s/it]/home/david/anaconda3/lib/python
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not converge
```
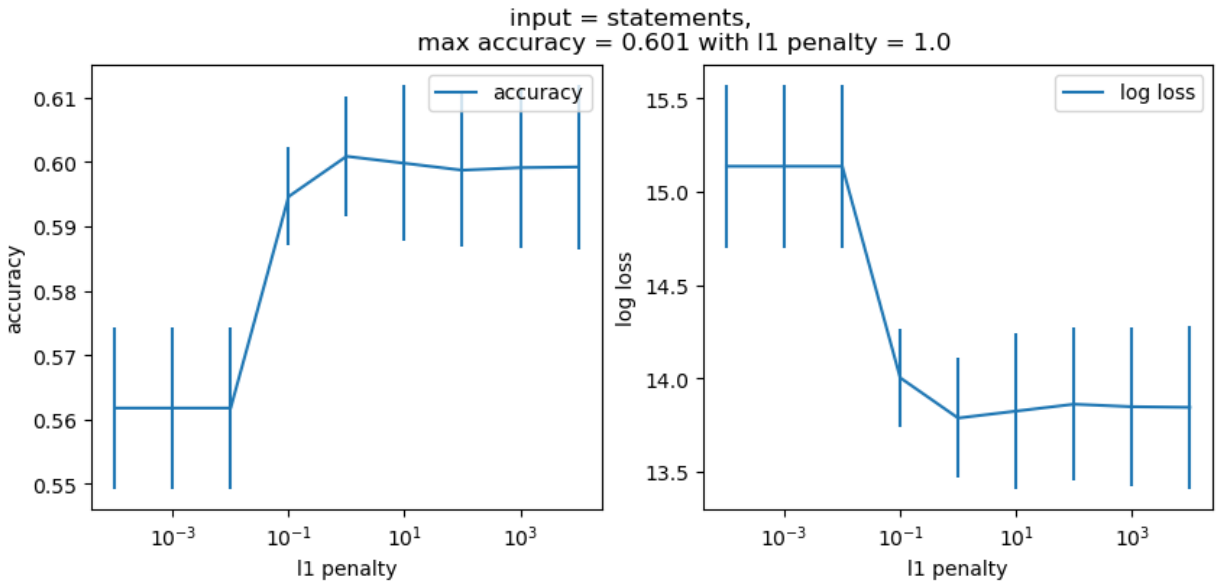

```
  warnings.warn(
100%|██████████| 9/9 [33:42<00:00, 224.71s/it]
```

Out[ ]:



In [ ]:

```
input_features = 'metadata'
X, X_headers = getXByfeatureOption(input_features, X0, X_headers0)

lasso_cv_acc_scores, lasso_cv_loss_scores = lasso_CV(X[::],
                                                     y[::],
                                                     n_fold = n_fold,
                                                     Cs = Cs,
                                                    random_state = random_stat
df_cv_score_agg = summarize_performance(Cs,n_fold,lasso_cv_acc_scores,lasso_cv
fig = plot_performance_df(df_cv_score_agg,input_features)

performance_df_dict[input_features] = df_cv_score_agg
performance_fig_dict[input_features] = fig
fig
```

```
 22%|██        | 2/9 [00:02<00:08,  1.26s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
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 33%|███       | 3/9 [00:06<00:15,  2.55s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
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 44%|████      | 4/9 [00:10<00:15,  3.16s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
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y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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 56%|█████▌    | 5/9 [00:14<00:14,  3.56s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
x_iter was reached which means the coef_ did not converge
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 67%|██████▋   | 6/9 [00:19<00:11,  3.82s/it]/home/david/anaconda3/lib/python
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  warnings.warn(
 78%|███████▊  | 7/9 [00:23<00:08,  4.00s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
x_iter was reached which means the coef_ did not converge
  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
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y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
not converge
  warnings.warn(
```

```
 89%|█████████ | 8/9 [00:28<00:04,  4.14s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
x_iter was reached which means the coef_ did not converge
  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
not converge
  warnings.warn(
100%|██████████| 9/9 [00:32<00:00,  3.60s/it]
```
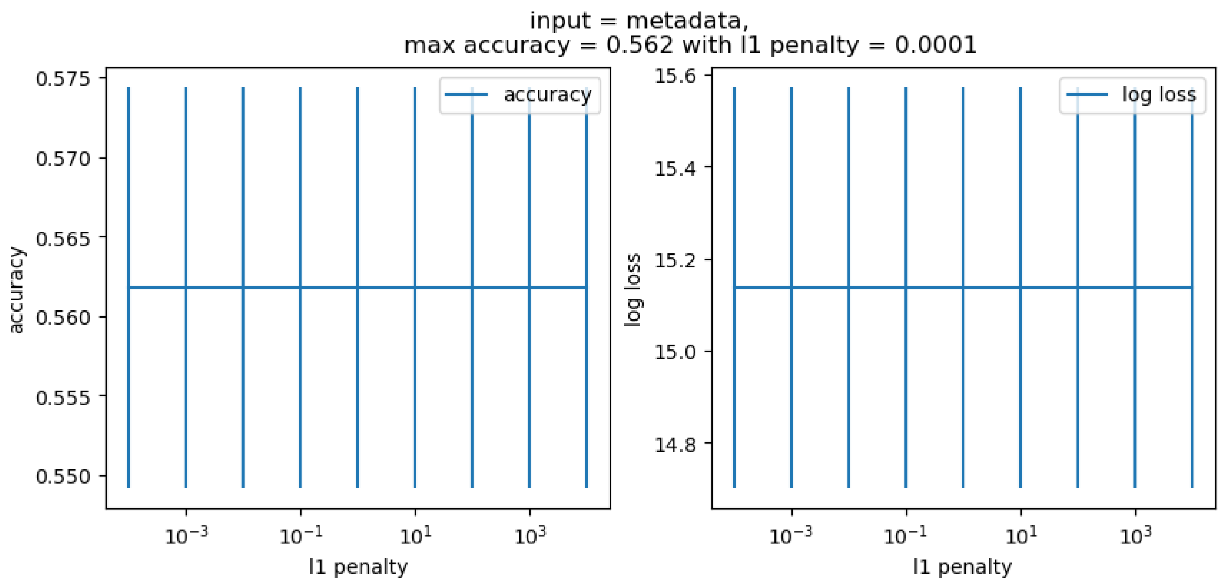

Out[ ]:



In [ ]:

```python
input_features = 'both'
X, X_headers = getXByfeatureOption(input_features, X0, X_headers0)

lasso_cv_acc_scores, lasso_cv_loss_scores = lasso_CV(X[::],
                                                      y[::],
                                                      n_fold = n_fold,
                                                      Cs = Cs,
                                                     random_stat
df_cv_score_agg = summarize_performance(Cs,n_fold,lasso_cv_acc_scores,lasso_cv
fig = plot_performance_df(df_cv_score_agg,input_features)

performance_df_dict[input_features] = df_cv_score_agg
performance_fig_dict[input_features] = fig
fig
```

```
 22%|██        | 2/9 [01:52<06:48, 58.37s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
x_iter was reached which means the coef_ did not converge
  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
not converge
  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
not converge
  warnings.warn(
 33%|███       | 3/9 [05:26<12:55, 129.30s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
x_iter was reached which means the coef_ did not converge
  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
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  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
not converge
  warnings.warn(
 44%|████▍     | 4/9 [09:06<13:44, 164.99s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
x_iter was reached which means the coef_ did not converge
  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
not converge
  warnings.warn(
```

```
 56%|█████     | 5/9 [14:45<15:11, 227.94s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
x_iter was reached which means the coef_ did not converge
  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
not converge
  warnings.warn(
 67%|██████    | 6/9 [20:53<13:46, 275.66s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
x_iter was reached which means the coef_ did not converge
  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
not converge
  warnings.warn(
 78%|███████   | 7/9 [27:07<10:15, 307.58s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
x_iter was reached which means the coef_ did not converge
  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
not converge
  warnings.warn(
```

```
 89%|█████████ | 8/9 [33:20<05:28, 328.62s/it]/home/david/anaconda3/lib/python
3.9/site-packages/sklearn/linear_model/_sag.py:350: ConvergenceWarning: The ma
x_iter was reached which means the coef_ did not converge
  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
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  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
not converge
  warnings.warn(
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
not converge
  warnings.warn(
100%|██████████| 9/9 [39:33<00:00, 263.76s/it]
```
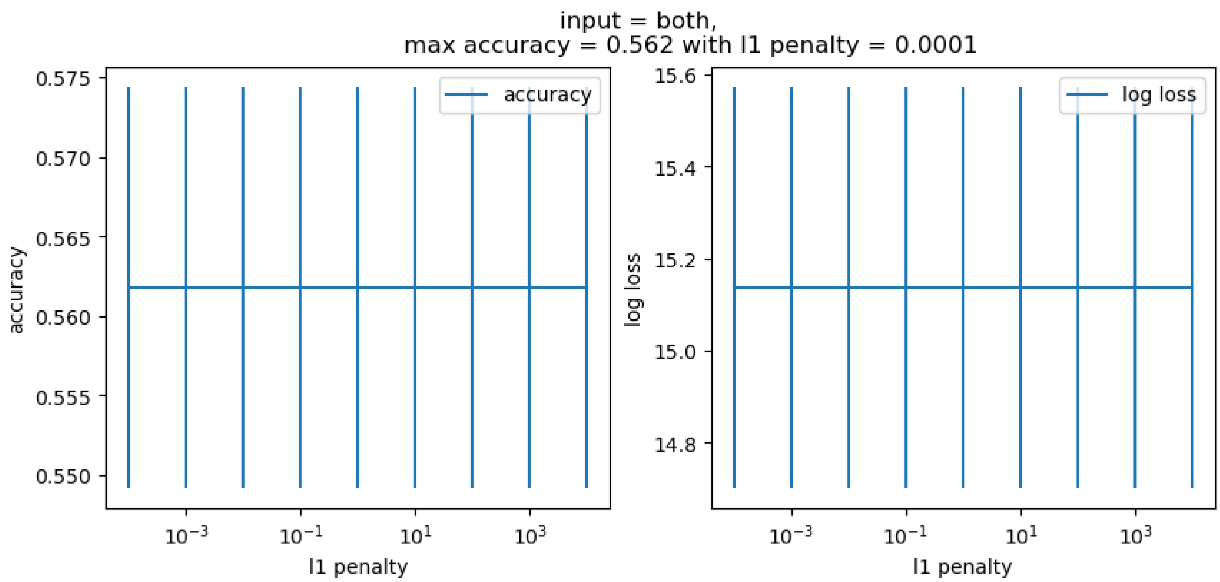

Out[ ]:



Analyze the best one, evaluate on the test set

In [ ]:

```
y_test,X_test0 = liar_liar_pre_processor.apply_encodings_to_new_data('test.tsv
```

```
/home/david/Documents/sta561project/modeling_logistic/../preprocess/Encoder.p
y:330: RuntimeWarning: invalid value encountered in true_divide
  weighted_credit_counts = credit_counts / sums[:,None]
```

In [ ]:

```
input_features = 'statements'
X, X_headers,X_test = getXByfeatureOption(input_features,
                                          X0,
                                          X_headers0,
                                          X_test0)

lasso = LogisticRegression(penalty='l1',
                           C=1,
                           solver='saga',
                           random_state=123)
```

In [ ]:
```
lasso = lasso.fit(X[::50],y[::50].flatten())
y_test_pred = lasso.predict(X_test).flatten()
test_acc =accuracy_score(y_test, y_test_pred)
test_confusion_matrix = confusion_matrix(y_test, y_test_pred)
print(f'test accuracy  {test_acc}')
print(f'test confusion matrix')
print(test_confusion_matrix )
```

```
test accuracy  0.5529225908372828
test confusion matrix
[[219 334]
 [232 481]]
```

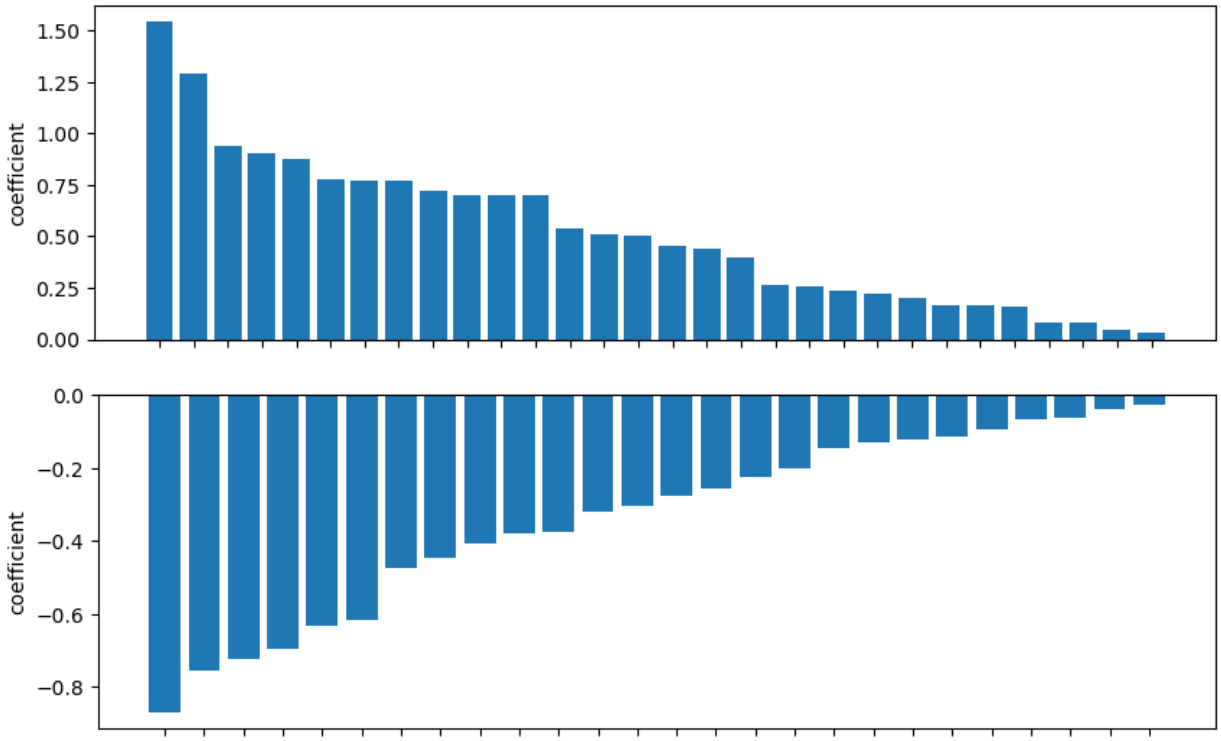
```
/home/david/anaconda3/lib/python3.9/site-packages/sklearn/linear_model/_sag.p
y:350: ConvergenceWarning: The max_iter was reached which means the coef_ did
not converge
  warnings.warn(
```

get the features with largest absolute coeficcient

In [ ]:
```
sort_idx = np.argsort(np.abs(lasso.coef_[0]))[::-1]
coef_sorted= lasso.coef_[0][sort_idx]
X_headers_sorted = np.array(X_headers)[sort_idx]

pos_coef_headers = X_headers_sorted[coef_sorted>0]
neg_coef_headers = X_headers_sorted[coef_sorted<0]

headers_0_coef = X_headers_sorted[coef_sorted == 0]

print('# positive coef feauters', len(pos_coef_headers))
print('# negative coef feauters', len(neg_coef_headers))
print('# 0 coef feauters', len(headers_0_coef ))
```

```
# positive coef feauters 30
# negative coef feauters 26
# 0 coef feauters 9959
```

In [ ]:
```
fig,ax  = plt.subplots(figsize=(10,3))
ax.bar(x = pos_coef_headers,
       height = coef_sorted[coef_sorted>0] )
ax.set_xticks(ax.get_xticks(), ax.get_xticklabels(), rotation=45, ha='right')
ax.set_ylabel('coefficient')
plt.show()


fig,ax  = plt.subplots(figsize=(10,3))
ax.bar(x = neg_coef_headers,
       height = coef_sorted[coef_sorted<0] )
ax.set_xticks(ax.get_xticks(), ax.get_xticklabels(), rotation=45, ha='right')
ax.set_ylabel('coefficient')
plt.show()
```


coefficient
1.50
1.25
1.00
0.75
0.50
0.25
0.00
coefficient
0.0
−0.2
−0.4
−0.6
−0.8