Autoimmune Tweets using Lemmatized Tweets with 8 categories of autoimmune diseases¶

to test on Celiac Disease with 2 classes instead of 8 Python 3.6 results, give a solid accuracy based on the data, but when generating probabilites for a set of random tweets outside the data table, give the exact results for all similar or not statements Those being: 1:Multiple Sclerosis, 2:Celiac, 3: Leukemia, 4: Hashimoto, 5: Fibromyalgia, 6: Kidney Disease, 7: Rheumatoid Arthritis, 8: Chron's Disease

Tweets were taken from respective diseases in early December 2019 from 13 to 119 tweets for each disease, as many as were found that weren't mostly marketing, using " treatment' in the search

In [1]:

```
%matplotlib inline

import pandas as pd

import matplotlib.pyplot as plt

from textblob import TextBlob

import sklearn

import numpy as np

from sklearn.feature_extraction.text import CountVectorizer

from sklearn.naive_bayes import MultinomialNB

from sklearn.metrics import classification_report, f1_score, accuracy_score, confusion
_matrix


np.random.seed(507)
```

In [2]:

```
reviews = pd.read_csv('TargetReady_noCuss-binaryAdded.csv', encoding = 'unicode_escape
')

#the encoding needed for python3 handling nonASCII chars
```

In [3]:

```
reviews.head()
```

Out[3]:

	Tweet	Type	Celiac_Not	Lkm_Not	Kd_Not	RA_Not		MS_Not
0	UNKNOWNResearchCa\r\n@UNKNOWN_ARC\r\n·\r\n19h\...	Rheumatoid Arthritis	not	not	not	RA		not

	Tweet	Type	Celiac_Not	Lkm_Not	Kd_Not	RA_Not		MS_Not
1	UNKNOWNatology Advisor\r\n@UNKNOWNAdvisor\r\n·...	Rheumatoid Arthritis	not	not	not	RA		not
2	UNKNOWN Community\r\n@our_UNKNOWN\r\n·\r\nDec ...	Rheumatoid Arthritis	not	not	not	RA		not
3	UNKNOWN National Research Foundation\r\n@CureU...	Rheumatoid Arthritis	not	not	not	RA		not
4	Orthopedic News\r\n@Orthopedics_Bio\r\n·\r\nDe...	Rheumatoid Arthritis	not	not	not	RA		not

In [4]:

```
reviews.tail()
```

Out[4]:

	Tweet	Type	Celiac_Not	Lkm_Not	Kd_Not	RA_Not	MS_Not	Chron_Not	Fibro_N
502	All Ezine\r\n@allezine\r\n·\r\nJun 13, 2011\r\...	Chron's Disease	not	not	not	not	not	Chron	not
503	Brian Coombes\r\n@BrianKCoombes\r\n·\r\nSep 6\...	Chron's Disease	not	not	not	not	not	Chron	not
504	Purpose ?\r\n@HappyBelieber\r\n·\r\nJan 19, 20...	Chron's Disease	not	not	not	not	not	Chron	not
505	K. Ketels-Lichtig\r\n@kklichtig\r\n·\r\nOct 25...	Chron's Disease	not	not	not	not	not	Chron	not
506	-DC-™\r\n @CURSE WORDwitdaDC\r\n·\r\nJul 8, 2...	Chron's Disease	not	not	not	not	not	Chron	not

In [5]:

```
reviews.shape
```

Out[5]:

```
(507, 10)
```

In [6]:

```
reviews = reviews.reindex(np.random.permutation(reviews.index))


print(reviews.head())
print(reviews.tail())
```

```
                                                 Tweet                Type  \
288  Aleksandar dr Petrov\r\n@aleksandar_BG\r\n·\r\...  Multiple Sclerosis
70   Beyond UNKNOWN\r\n@BeyondUNKNOWN\r\n·\r\nSep 1...      Celiac Disease
184  #HandsOffVenezuela\r\n@ChicoFreedom\r\n·\r\nDe...             Leukemia
459  Adult & Pediatric Ear, Nose & Throat\r\n@EarAd...   Hashimoto Disease
448  Angela J. White\r\n@50Plushealths\r\n·\r\nDec ...        Fibromyalgia

    Celiac_Not Lkm_Not Kd_Not RA_Not MS_Not Chron_Not Fibro_Not Hashi_Not
288        not     not    not    not     MS       not       not       not
70      celiac     not    not    not    not       not       not       not
184        not     Lkm    not    not    not       not       not       not
459        not     not    not    not    not       not       not     Hashi
448        not     not    not    not    not       not     fibro       not
```

```
                                                 Tweet                Type  \
136  CURE Magazine\r\n@cure_magazine\r\n·\r\nDec 3\...            Leukemia
503  Brian Coombes\r\n@BrianKCoombes\r\n·\r\nSep 6\...     Chron's Disease
295  Glynis Edwards\r\n@Glynis4B12\r\n·\r\nNov 26\r...  Multiple Sclerosis
452  Mavz\r\n@mattymavz\r\n·\r\nNov 5, 2018\r\nIt's...        Fibromyalgia
112  GrupoCronosSEFH\r\n@GRUPOCRONOSSEF1\r\n·\r\nDe...      Kidney Disease

    Celiac_Not Lkm_Not Kd_Not RA_Not MS_Not Chron_Not Fibro_Not Hashi_Not
136        not     Lkm    not    not    not       not       not       not
503        not     not    not    not    not     Chron       not       not
295        not     not    not    not     MS       not       not       not
452        not     not    not    not    not       not     fibro       not
112        not     not     Kd    not    not       not       not       not
```

In [7]:

```
reviews.groupby('Type').describe()
```

Out[7]:

	Tweet				Celiac_Not				Lkm_Not		...	Chron_N	
	count	unique	top	freq	count	unique	top	freq	count	unique	...	top	fre
Type													
Celiac Disease	50	50	Vicki\r\n@vvanblaricum\r\n·\r\nDec 2\r\nReplyi...	1	50	1	celiac	50	50	1	...	not	50
Chron's Disease	19	19	Lift Resource Centre\r\n@liftcentre\r\n·\r\nJu...	1	19	1	not	19	19	1	...	Chron	19
Fibromyalgia	99	96	Fibro Bloggers\r\n@FibroBloggers\r\n·\r\nNov 2...	2	99	1	not	99	99	1	...	not	99
Hashimoto Disease	30	29	Colorado Natural Med\r\n@drgravesCO\r\n·\r\nDe...	2	30	1	not	30	30	1	...	not	30
Kidney Disease	43	43	Cleveland Clinic MD\r\n@CleClinicMD\r\n·\r\nDe...	1	43	1	not	43	43	1	...	not	43
Leukemia	119	119	Medivizor\r\n@medivizor\r\n·\r\nNov 28\r\nCopi...	1	119	1	not	119	119	1	...	not	11
Multiple Sclerosis	119	119	Cannabis Industry UK\r\n@CannaIndustryuk\r\n·\...	1	119	1	not	119	119	1	...	not	11
Rheumatoid Arthritis	28	28	Jessica Daitch\r\n@JessinCharlotte\r\n·\r\nSep...	1	28	1	not	28	28	1	...	not	28

8 rows × 36 columns

In [8]:

```
reviews['length'] = reviews['Tweet'].map(lambda text: len(text))

print(reviews.head())
```

```
                                                 Tweet                Type  \
288  Aleksandar dr Petrov\r\n@aleksandar_BG\r\n·\r\...  Multiple Sclerosis
70   Beyond UNKNOWN\r\n@BeyondUNKNOWN\r\n·\r\nSep 1...      Celiac Disease
184  #HandsOffVenezuela\r\n@ChicoFreedom\r\n·\r\nDe...            Leukemia
459  Adult & Pediatric Ear, Nose & Throat\r\n@EarAd...   Hashimoto Disease
448  Angela J. White\r\n@50Plushealths\r\n·\r\nDec ...        Fibromyalgia

    Celiac_Not Lkm_Not Kd_Not RA_Not MS_Not Chron_Not Fibro_Not Hashi_Not  \
288        not     not    not    not     MS       not       not       not
70      celiac     not    not    not    not       not       not       not
184        not     Lkm    not    not    not       not       not       not
```

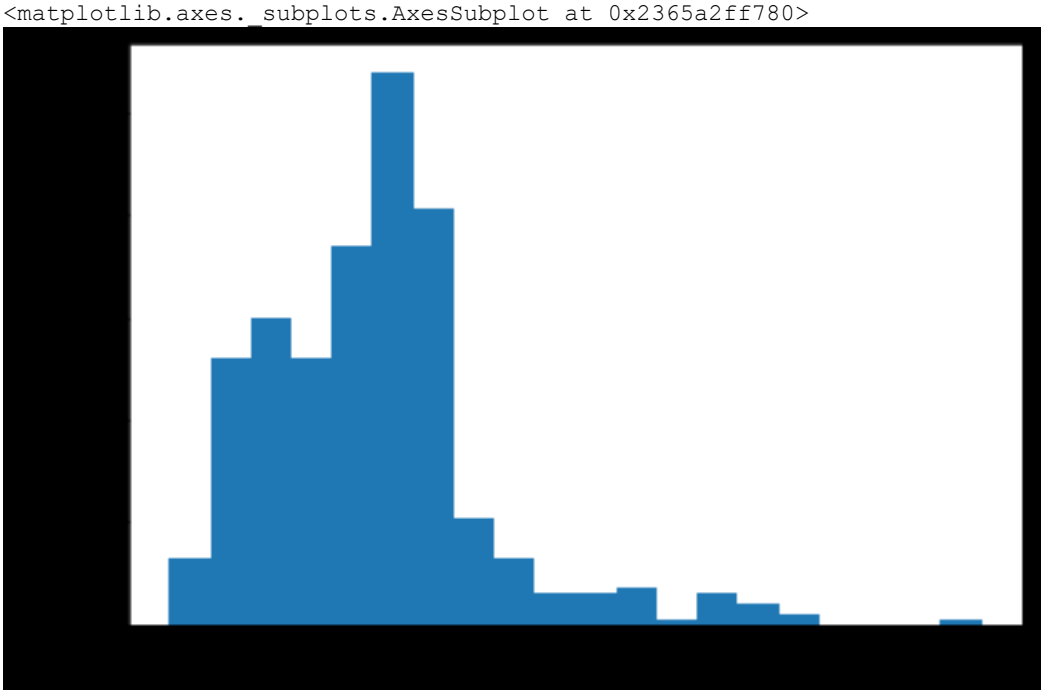
```
459        not     not    not    not    not       not       not     Hashi
448        not     not    not    not    not       not     fibro       not

     length
288     281
70      247
184     317
459     142
448     255
```

In [9]:

```
reviews.length.plot(bins=20, kind='hist')
```

Out[9]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2365a2ff780>
```



In [10]:

```
reviews.length.describe()
```

Out[10]:

```
count    507.000000
mean     276.568047
std      104.552353
min       87.000000
25%      201.500000
50%      279.000000
75%      320.500000
max      847.000000
Name: length, dtype: float64
```

In [11]:

```
print(list(reviews.Tweet[reviews.length > 700].index)) #near the max for length of Lem
matizedTweets
```

```
print(list(reviews.Type[reviews.length > 700]))

print(list(reviews.Tweet[reviews.length > 700]))
```

```
[151]
['Leukemia']
['BTS Mauritius\r\n@BTSMauritius\r\n·\r\n19h\r\nThe Korea Leukemia Children\x92s Found
ation announced that 553 ARMYs donated blood in honour of @BTS_twt\r\n\x92s Jin birthd
ay!\r\n\r\nIt\x92ll be used for children with cancer who need to receive large blood t
ransfusions during treatment, helping to ease the burden of costs for patients\x92 fam
ilies.\r\nQuote Tweet\r\n??????\r\n??\r\n??\r\n@_nojam_nolife\r\n · Dec 3\r\n????? ? ?
?, ?? ?? ??? ??(??)  \r\n??\r\nhttp://entertain.v.daum.net/v/20191204091525391\r\n\r\n
#????? #BTS @BTS_twt \r\n\r\n??????????? ?????? ????? ? ????? ?? ?? ??? 12? 4? ????? ?
? ???? ?? ??? ???? ??? 553?? ????? ???.\r\nImage\r\nImage\r\nImage\r\nImage\r\nImpriso
ned Babies\r\n@aptlmetin\r\n·\r\nDec 3\r\nAkif Acute Lymphoblastic Leukemia patient. H
e is going through a heavy treatment process. He needs medicare. Let mom?enay DA?TAN h
ave her trial without arrest!\r\n#InternationalDisabilityDay ']
```

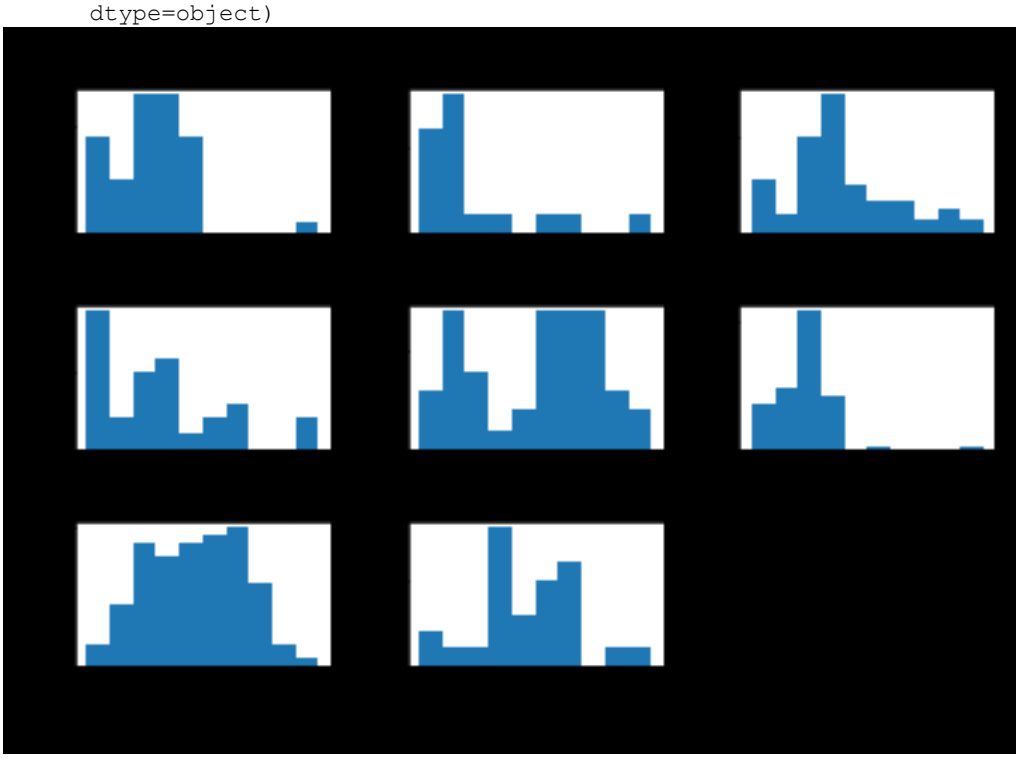
In [12]:

```
%%time

reviews.hist(column='length', by='Type', bins=10)
```

```
Wall time: 516 ms
```

Out[12]:

```
array([[<matplotlib.axes._subplots.AxesSubplot object at 0x000002365A426518>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000002365A46BBA8>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000002365A4A3198>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x000002365A4D3748>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000002365A504C88>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000002365A544278>],
       [<matplotlib.axes._subplots.AxesSubplot object at 0x000002365A575828>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000002365A5A6E10>,
        <matplotlib.axes._subplots.AxesSubplot object at 0x000002365A5A6E48>]],
      dtype=object)
```



In [13]:

```
def split_into_tokens(review):


    #review = unicode(review, 'iso-8859-1')# in python 3 the default of str() previous
ly python2 as unicode() is utf-8

    return TextBlob(review).words
```

In [14]:

```
reviews.Tweet.head().apply(split_into_tokens)
```

Out[14]:

```
288    [Aleksandar, dr, Petrov, aleksandar_BG, ·, Dec...
70     [Beyond, UNKNOWN, BeyondUNKNOWN, ·, Sep, 17, 2...
184    [HandsOffVenezuela, ChicoFreedom, ·, Dec, 2, o...
459    [Adult, Pediatric, Ear, Nose, Throat, EarAdult...
448    [Angela, J, White, 50Plushealths, ·, Dec, 15, ...
Name: Tweet, dtype: object
```

In [15]:

```
TextBlob("hello world, how is it going?").tags
```

Out[15]:

```
[('hello', 'JJ'),
 ('world', 'NN'),
 ('how', 'WRB'),
 ('is', 'VBZ'),
 ('it', 'PRP'),
 ('going', 'VBG')]
```

In [16]:

```
import nltk

nltk.download('stopwords')
```

```
[nltk_data] Downloading package stopwords to
[nltk_data]     C:\Users\m\AppData\Roaming\nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

Out[16]:

```
True
```

In [17]:

```
from nltk.corpus import stopwords


stop = stopwords.words('english')

stop = stop + [u'a',u'b',u'c',u'd',u'e',u'f',u'g',u'h',u'i',u'j',u'k',u'l',u'm',u'n',u
'o',u'p',u'q',u'r',u's',u't',u'v',u'w',u'x',u'y',u'z']
```

In [18]:

```
def split_into_lemmas(review):
    #review = unicode(review, 'iso-8859-1')
    review = review.lower()
    #review = unicode(review, 'utf8').lower()
    #review = str(review).lower()
    words = TextBlob(review).words
    # for each word, take its "base form" = lemma
    return [word.lemma for word in words if word not in stop]

reviews.Tweet.head().apply(split_into_lemmas)
```

Out[18]:

```
288    [aleksandar, dr, petrov, aleksandar_bg, ·, dec...
70     [beyond, unknown, beyondunknown, ·, sep, 17, 2...
184    [handsoffvenezuela, chicofreedom, ·, dec, 2, o...
459    [adult, pediatric, ear, nose, throat, earadult...
448    [angela, white, 50plushealths, ·, dec, 15, 201...
Name: Tweet, dtype: object
```

In [19]:

```
# Celiac or Not classes


#%%time
bow_transformer = CountVectorizer(analyzer=split_into_lemmas, ngram_range=(1,4)).fit(r
eviews['Tweet'])
print(len(bow_transformer.vocabulary_))
```

```
4792
```

In [20]:

```
bow_transformer
```

Out[20]:

```
CountVectorizer(analyzer=<function split_into_lemmas at 0x000002365C19DAE8>,
                binary=False, decode_error='strict',
                dtype=<class 'numpy.int64'>, encoding='utf-8', input='content',
                lowercase=True, max_df=1.0, max_features=None, min_df=1,
                ngram_range=(1, 4), preprocessor=None, stop_words=None,
                strip_accents=None, token_pattern='(?u)\\b\\w\\w+\\b',
                tokenizer=None, vocabulary=None)
```

In [21]:

```
review4 = reviews['Tweet'][148]
print(review4)
```

```
Peking University
@PKU1898
```

```
.
Nov 30
Published in Cold Spring Harbor Perspectives in Medicine, #Peking University□s Wu Hong
and team analyzed connections between a tumor suppressing gene called PTEN, the format
ion of blood cell components, and leukemia. #PekingScience
```

In [22]:

```
bow4 = bow_transformer.transform([review4])

print(bow4)
```

```
  (0, 113)       1
  (0, 371)       1
  (0, 705)       1
  (0, 816)       1
  (0, 898)       1
  (0, 1023)      1
  (0, 1062)      1
  (0, 1085)      1
  (0, 1780)      1
  (0, 1846)      1
  (0, 1990)      1
  (0, 2095)      1
  (0, 2545)      1
  (0, 2788)      1
  (0, 3111)      1
  (0, 3303)      2
  (0, 3304)      1
  (0, 3330)      1
  (0, 3369)      1
  (0, 3533)      1
  (0, 3535)      1
  (0, 4022)      1
  (0, 4140)      1
  (0, 4205)      1
  (0, 4401)      1
  (0, 4472)      1
  (0, 4474)      1
  (0, 4729)      1
  (0, 4790)      1
```

In [23]:

```
%%time

reviews_bow = bow_transformer.transform(reviews['Tweet'])

print('sparse matrix shape:', reviews_bow.shape)

print('number of non-zeros:', reviews_bow.nnz)

print('sparsity: %.2f%%' % (100.0 * reviews_bow.nnz / (reviews_bow.shape[0] * reviews_
bow.shape[1])))
```

```
sparse matrix shape: (507, 4792)
number of non-zeros: 12995
sparsity: 0.53%
Wall time: 1 s
```

In [24]:

```
# Split/splice into training ~ 80% and testing ~ 20%
```

```
reviews_bow_train = reviews_bow[:400]

reviews_bow_test = reviews_bow[400:]

reviews_sentiment_train = reviews['Celiac_Not'][:400]

reviews_sentiment_test = reviews['Celiac_Not'][400:]


print(reviews_bow_train.shape)

print(reviews_bow_test.shape)
```

```
(400, 4792)
(107, 4792)
```

In [25]:

```
%time review_sentiment = MultinomialNB().fit(reviews_bow_train, reviews_sentiment_trai
n)
```

```
Wall time: 15.6 ms
```

In [26]:

```
print('predicted:', review_sentiment.predict(bow4)[0])

print('expected:', reviews.Celiac_Not[151])
```

```
predicted: not
expected: not
```

In [27]:

```
predictions = review_sentiment.predict(reviews_bow_test)

print(predictions)
```

```
['not' 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'not'
 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'celiac' 'not' 'not'
 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'celiac' 'not'
 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'celiac' 'not' 'not' 'not'
 'not' 'not' 'celiac' 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'not'
 'not' 'not' 'not' 'not' 'celiac' 'not' 'not' 'not' 'not' 'not' 'not'
 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'celiac' 'not' 'not' 'not'
 'celiac' 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'not'
 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'not' 'celiac'
 'not' 'not' 'not' 'not' 'not' 'not' 'not']
```

In [28]:

```
print('accuracy', accuracy_score(reviews_sentiment_test, predictions))

print('confusion matrix\n', confusion_matrix(reviews_sentiment_test, predictions))

print('(row=expected, col=predicted)')
```

```
accuracy 0.8878504672897196
confusion matrix
 [[ 1  5]
 [ 7 94]]
(row=expected, col=predicted)
```

In [29]:

```
print(classification_report(reviews_sentiment_test, predictions))

#The F1 score can be interpreted as a weighted average of the precision and recall,

#where an F1 score reaches its best value at 1 and worst score at 0.
```

```
              precision    recall  f1-score   support

      celiac       0.12      0.17      0.14         6
         not       0.95      0.93      0.94       101

    accuracy                           0.89       107
   macro avg       0.54      0.55      0.54       107
weighted avg       0.90      0.89      0.90       107
```

In [30]:

```
def predict_review(new_review):

    new_sample = bow_transformer.transform([new_review])

    print(new_review, '\nThe respective order new or pro probabilities:\n',np.around(r
eview_sentiment.predict_proba(new_sample), decimals=2),'\n')
```

The probabilities of being Celiac Disease or not are in alphabetical order for [Celiac Disease, Not]¶

In [32]:

```
predict_review('driving to the hospital.')


predict_review('stomach aches.')


predict_review('gluten.')

predict_review('bring home some coffee.')

#a snippet of an actual tweet from RA

predict_review('carbs galore')
```

```
driving to the hospital.
The respective order new or pro probabilities:
 [[0.07 0.93]]

stomach aches.
The respective order new or pro probabilities:
 [[0.11 0.89]]

gluten.
The respective order new or pro probabilities:
 [[0.58 0.42]]
```

```
bring home some coffee.
The respective order new or pro probabilities:
 [[0.16 0.84]]

carbs galore
The respective order new or pro probabilities:
 [[0.38 0.62]]
```

In [ ]: