6. How many iterations are required to separate the training data? Which number of iterations is likely to represent the best tradeoff between fitting the data and not overfitting?

With tuning parameter when adjust the weight, 28 times to converge
15 times are the best tradeoff between fitting the data and not overfitting.

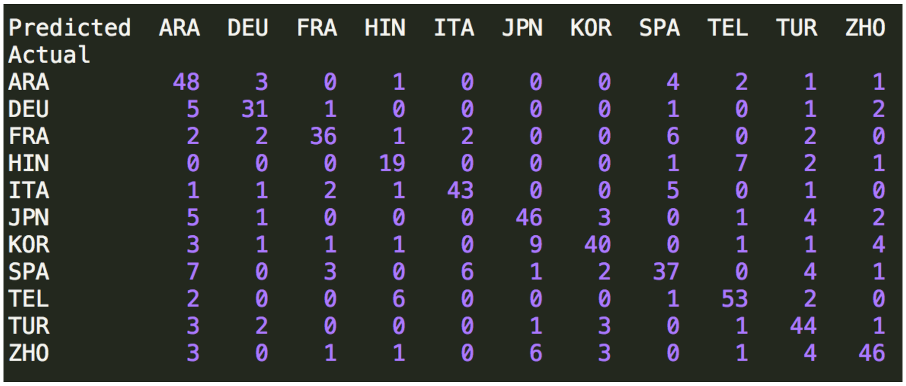
7. Feature Engineering: Add 3 different features

- word n-grams (n = 2)
- lemmas
- lowercase normalization
- unigram

Model	trainAcc	devAcc	testAcc	params	iteration(I)
All in	0.9996272828922848	0.7374581939799331	0.7317880794701986	934293	11
Minus unigram	0.9998136414461424	0.7558528428093646	0.7152317880794702	930481	12
Minus lemmatizer	0.9986954901229966	0.7441471571906354	0.7235099337748344	968862	11
Minus 2-gram	0.9998136414461424	0.7006688963210702	0.6837748344370861	152961	15
Minus lower	0.9994409243384271	0.7324414715719063	0.7284768211920529	933357	11
Best Model Unigram+2-gram+lemmatizer+ lower	0.9996272828922848	0.7374581939799331	0.7317880794701986	934293	11

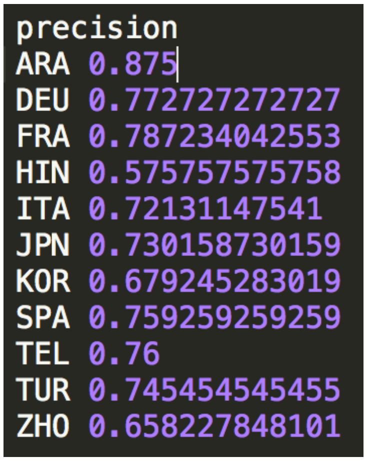
8. Error Analysis: Best Model

a. Confusion Matrix

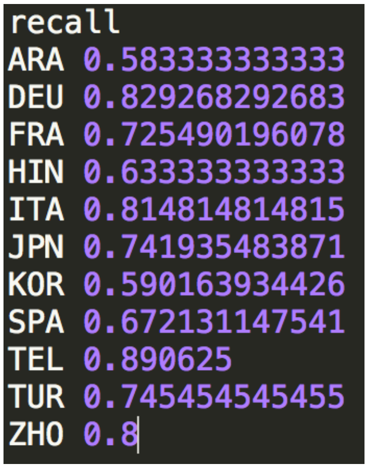


```
Predicted  ARA  DEU  FRA  HIN  ITA  JPN  KOR  SPA  TEL  TUR  ZHO
Actual
ARA         48    3    0    1    0    0    0    4    2    1    1
DEU          5   31    1    0    0    0    0    1    0    1    2
FRA          2    2   36    1    2    0    0    6    0    2    0
HIN          0    0    0   19    0    0    0    1    7    2    1
ITA          1    1    2    1   43    0    0    5    0    1    0
JPN          5    1    0    0    0   46    3    0    1    4    2
KOR          3    1    1    1    0    9   40    0    1    1    4
SPA          7    0    3    0    6    1    2   37    0    4    1
TEL          2    0    0    6    0    0    0    1   53    2    0
TUR          3    2    0    0    0    1    3    0    1   44    1
ZHO          3    0    1    1    0    6    3    0    1    4   46
```

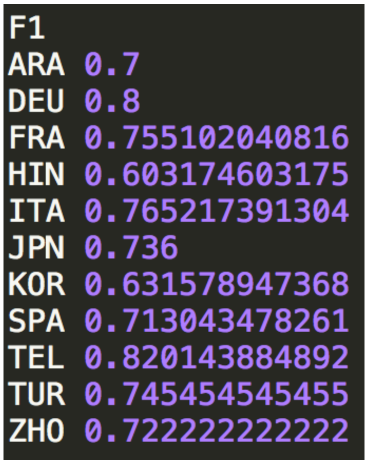
c. Recall, Precision, F1



```
precision
ARA 0.875
DEU 0.772727272727
FRA 0.787234042553
HIN 0.575757575758
ITA 0.72131147541
JPN 0.730158730159
KOR 0.679245283019
SPA 0.759259259259
TEL 0.76
TUR 0.745454545455
ZHO 0.658227848101
```



```
recall
ARA 0.583333333333
DEU 0.829268292683
FRA 0.725490196078
HIN 0.633333333333
ITA 0.814814814815
JPN 0.741935483871
KOR 0.590163934426
SPA 0.672131147541
TEL 0.890625
TUR 0.745454545455
ZHO 0.8
```



```
F1
ARA 0.7
DEU 0.8
FRA 0.755102040816
HIN 0.603174603175
ITA 0.765217391304
JPN 0.736
KOR 0.631578947368
SPA 0.713043478261
TEL 0.820143884892
TUR 0.745454545455
ZHO 0.722222222222
```

b. 10 Highest vs 10 Lowest Weights & Bias Weight

HIN

Highest	Lowest	Biased – ‘ajdif7af’
then 2.600000000000001 which 2.3000000000000007 but 2.1000000000000005 its 2.0000000000000004 of life 2.0000000000000004 field 1.9000000000000006 start 1.9000000000000006 today 1.9000000000000004 behind 1.8000000000000005 towards 1.8000000000000003	finally -2.700000000000001 For example -2.3000000000000007 know -1.9000000000000004 and the -1.9000000000000004 nowadays -1.7000000000000004 reasons -1.6000000000000003 may not -1.5000000000000002 there -1.5000000000000002 to get -1.4000000000000001 such a -1.3	-0.10000000000000003

DEU

Highest	Lowest	Biased – ‘ajdif7af’
statement 2.2000000000000006 often 2.2000000000000006 possibility 1.9000000000000006 special 1.9000000000000004 question 1.8000000000000005 beeing 1.8000000000000005 the statement 1.7000000000000004 there 1.7000000000000004 get 1.7000000000000002	we -2.9000000000000012 particular -1.6000000000000003 however -1.5000000000000002 However -1.5000000000000002 we are -1.5000000000000002 major -1.4000000000000001 Secondly -1.3 world -1.3 and they -1.3	-0.6

But 1.6000000000000003	study -1.3	

JPN

Highest	Lowest	Biased – ‘ajdif7af’
japan 4.000000000000002 Japan 3.800000000000002 I think 3.1000000000000014 If 2.800000000000001 in Japan 2.500000000000001 japanese 2.400000000000001 I disagree 2.3000000000000007 I agree 2.1000000000000005 Japanese 2.1000000000000005 especially 2.1000000000000005	an -2.9000000000000012 every -2.500000000000001 last -2.400000000000001 maybe -2.2000000000000006 and to -2.2000000000000006 will -2.1000000000000005 be a -2.1000000000000005 you -1.9000000000000004 time -1.9000000000000004 all the -1.8000000000000005	0.5

FRA

Highest	Lowest	Biased – ‘ajdif7af’
indeed 3.4000000000000017 is a 2.9000000000000012 Indeed 2.600000000000001 during 2.2000000000000006 by 2.1000000000000005 instance 2.0000000000000004 even if 2.0000000000000004 think that 2.0000000000000004 differents 1.8000000000000005 one hand 1.7000000000000004	the idea -2.400000000000001 the people -2.1000000000000005 this is -2.0000000000000004 I -1.9000000000000006 the statement -1.9000000000000004 If -1.7000000000000004 in life -1.6000000000000003 information -1.6000000000000003 times -1.6000000000000003 should -1.6000000000000003	-0.19999999999999998

TUR

Highest	Lowest	Biased – ‘ajdif7af’
can not 3.3000000000000016 Because 2.9000000000000012 being 2.700000000000001 turkey 2.400000000000001 about 2.400000000000001	study -2.2000000000000006 a lot -2.1000000000000005 will -2.1000000000000005 often -2.1000000000000005 case -1.9000000000000006	2.7755575615628914e-17

conditions 2.3000000000000007 easily 2.3000000000000007 idea 2.2000000000000006 Turkey 2.2000000000000006 As a 2.2000000000000006	agree with -1.8000000000000005 out -1.8000000000000005 statement -1.6000000000000003 learn fact -1.6000000000000003 could -1.6000000000000003	

ARA

Highest	Lowest	Biased – ‘ajdif7af’
alot 3.4000000000000017 and the 2.9000000000000012 any 2.700000000000001 alot of 2.600000000000001 statment 2.400000000000001 from 2.1000000000000005 thier 2.1000000000000005 Also 2.0000000000000004 many reason 1.9000000000000006 will 1.9000000000000004	often -2.2000000000000006 possible -2.2000000000000006 of the -2.1000000000000005 seems -1.9000000000000006 can be -1.9000000000000004 been -1.8000000000000005 If -1.8000000000000003 much -1.7000000000000004 knowledge -1.7000000000000004 it is -1.7000000000000002	0.30000000000000004

ITA

Highest	Lowest	Biased – ‘ajdif7af’
think that 3.1000000000000014 probably 2.500000000000001 people that 2.400000000000001 infact 2.400000000000001 that in 2.2000000000000006 possibility to 2.1000000000000005 I think 2.1000000000000005 man 2.0000000000000004 possibility 2.0000000000000004 problems 1.9000000000000004	may -2.3000000000000007 over -2.0000000000000004 do not -2.0000000000000004 Because -1.9000000000000006 get -1.9000000000000004 But -1.7000000000000004 would -1.7000000000000004 anything -1.7000000000000004 him -1.6000000000000003 which -1.6000000000000003	0.30000000000000004

ZHO

Highest	Lowest	Biased – ‘ajdif7af’
still 3.0000000000000013	the other -2.700000000000001	-0.5

will 2.400000000000001 may 2.3000000000000007 is a 2.2000000000000006 china 2.1000000000000005 but not 2.1000000000000005 Take 2.1000000000000005 just 2.1000000000000005 three 2.0000000000000004 maybe 1.9000000000000006	an -2.600000000000001 and that -2.0000000000000004 have a -1.9000000000000006 its -1.9000000000000004 expensive -1.8000000000000005 have to -1.8000000000000003 working -1.7000000000000004 try to -1.7000000000000004 if they -1.7000000000000004	

KOR

Highest	Lowest	Biased – ‘ajdif7af’
korea 3.700000000000002 out 3.0000000000000013 Korea 2.800000000000001 However 2.700000000000001 however 2.400000000000001 various 2.2000000000000006 company 2.1000000000000005 famous 2.1000000000000005 just 2.1000000000000005 these day 2.0000000000000004	take -2.500000000000001 think that -2.3000000000000007 in the -2.1000000000000005 by the -2.0000000000000004 issue -1.9000000000000004 how -1.9000000000000004 the same -1.8000000000000005 only -1.7000000000000002 japan -1.6000000000000003 a person -1.6000000000000003	-0.30000000000000004

SPA

Highest	Lowest	Biased – ‘ajdif7af’
going to 2.400000000000001 people is 2.0000000000000004 the city 2.0000000000000004 are going 1.9000000000000006 that are 1.8000000000000005 example of 1.7000000000000004 not know 1.7000000000000004 going 1.7000000000000004 things 1.7000000000000004 enviroment 1.7000000000000004	which -3.0000000000000013 might -2.2000000000000006 from -2.2000000000000006 especially -2.1000000000000005 still -2.1000000000000005 by -2.0000000000000004 even if -2.0000000000000004 the fact -1.9000000000000006 on -1.9000000000000004 successful -1.9000000000000004	0.10000000000000003

TEL

Highest	Lowest	Biased – ‘ajdif7af’
finally 3.0000000000000013 some 2.2000000000000006 may 2.2000000000000006 by 2.2000000000000006 the statement 2.2000000000000006 conclude 2.1000000000000005 may not 2.1000000000000005 cannot 2.0000000000000004 strongly 2.0000000000000004 about the 2.0000000000000004	I think -2.800000000000001 just -2.3000000000000007 have to -2.1000000000000005 first -2.0000000000000004 or -1.8000000000000003 big -1.7000000000000004 however -1.7000000000000004 of life -1.7000000000000004 think that -1.7000000000000004 say -1.7000000000000002	0.5

What are some of the patterns you observe? Do the bias feature weights behave like priors in naïve Bayes—why or why not?

According to the confusion matrix, between some languages there are high chances of predicting wrongly to each other, such as KOR and JPN, SPA and ITA, referring the similarity between those languages.

Also from the top 10 word lists, country name appears in the list for many languages, so apparently it’s an important percept.

The bias feature in perceptron seems different from the prior probabilities, because the latter in NB won’t change and behaves as a stable factor for calculating the joint probability, while the bias feature in Perceptron is for error tuning purpose.

9. Bonus

```
python perceptron_a.py –a 30
```

The test result of average method is not as good as the former model.