Disciplina: Data Mining **Data:** 4/11/2016

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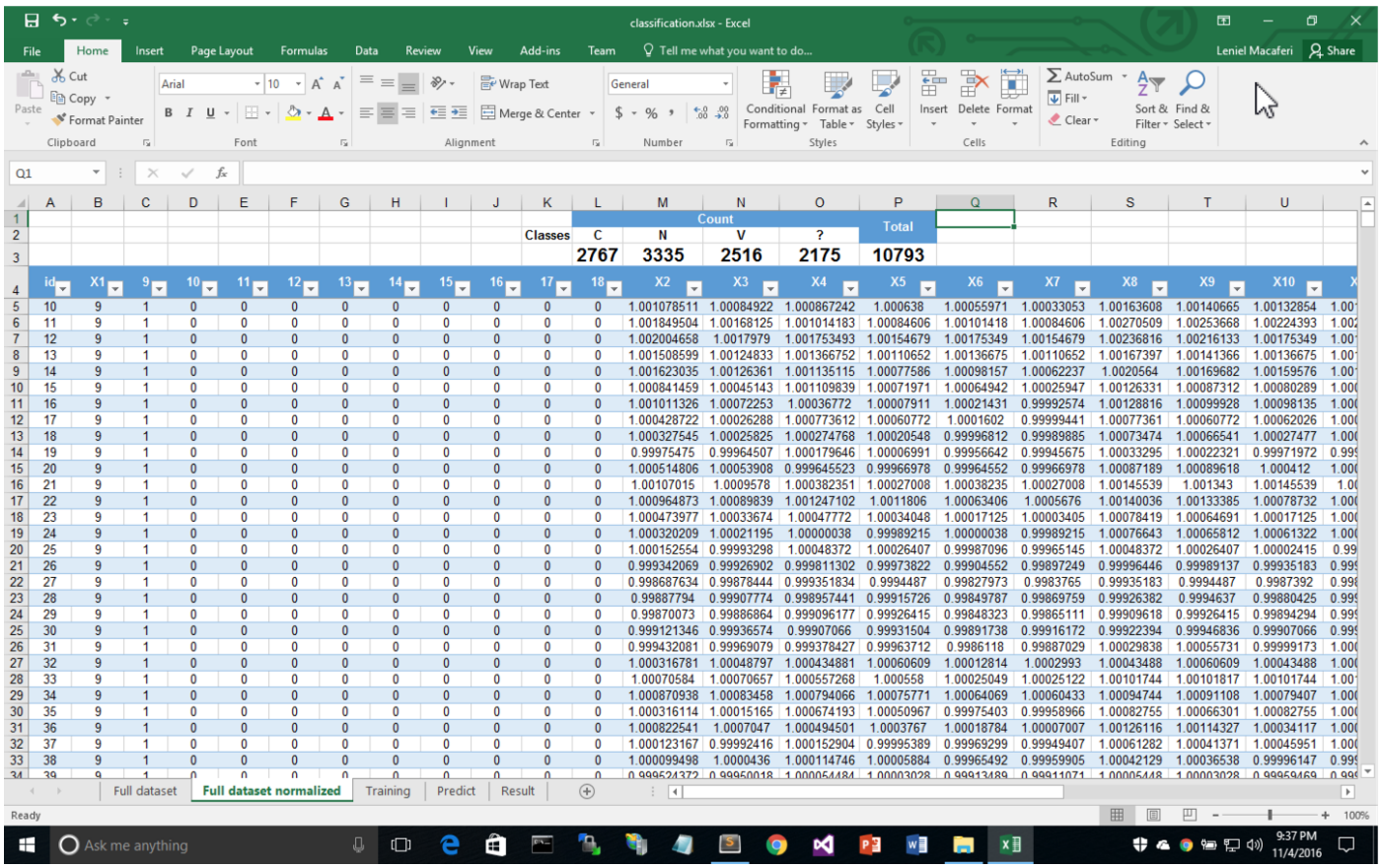
Report
Classification

The test was conducted using a spreadsheet named [classification.xlsx] containing 10793 data samples as shown in the following screenshot:



Column X1 and X12 were normalized.

X1 presented values ranging from 9 to 18. The approach taken was to create new feature columns, one for each value in this range. Boolean values were assigned to each row accordingly.

X12 presented dissonant values ranging from 14.23 to -1.06 and as such they were normalized between 0 to 1. This process is important to make the data more conformant\balanced with other existing features (columns) allowing the classifiers to do a better job.

Number crunching was done in Microsoft Excel before serving as input to the classifiers' algorithms.

Development was done using Visual Studio Code as the IDE and Python programming language with scikit-learn Machine Learning library, NumPy and Pandas.

Source code is available @ https://github.com/leniel/DataMining

Useful reading

Naive Bayes http://scikit-learn.org/stable/modules/naive_bayes.html

SVM http://scikit-learn.org/stable/modules/svm.html

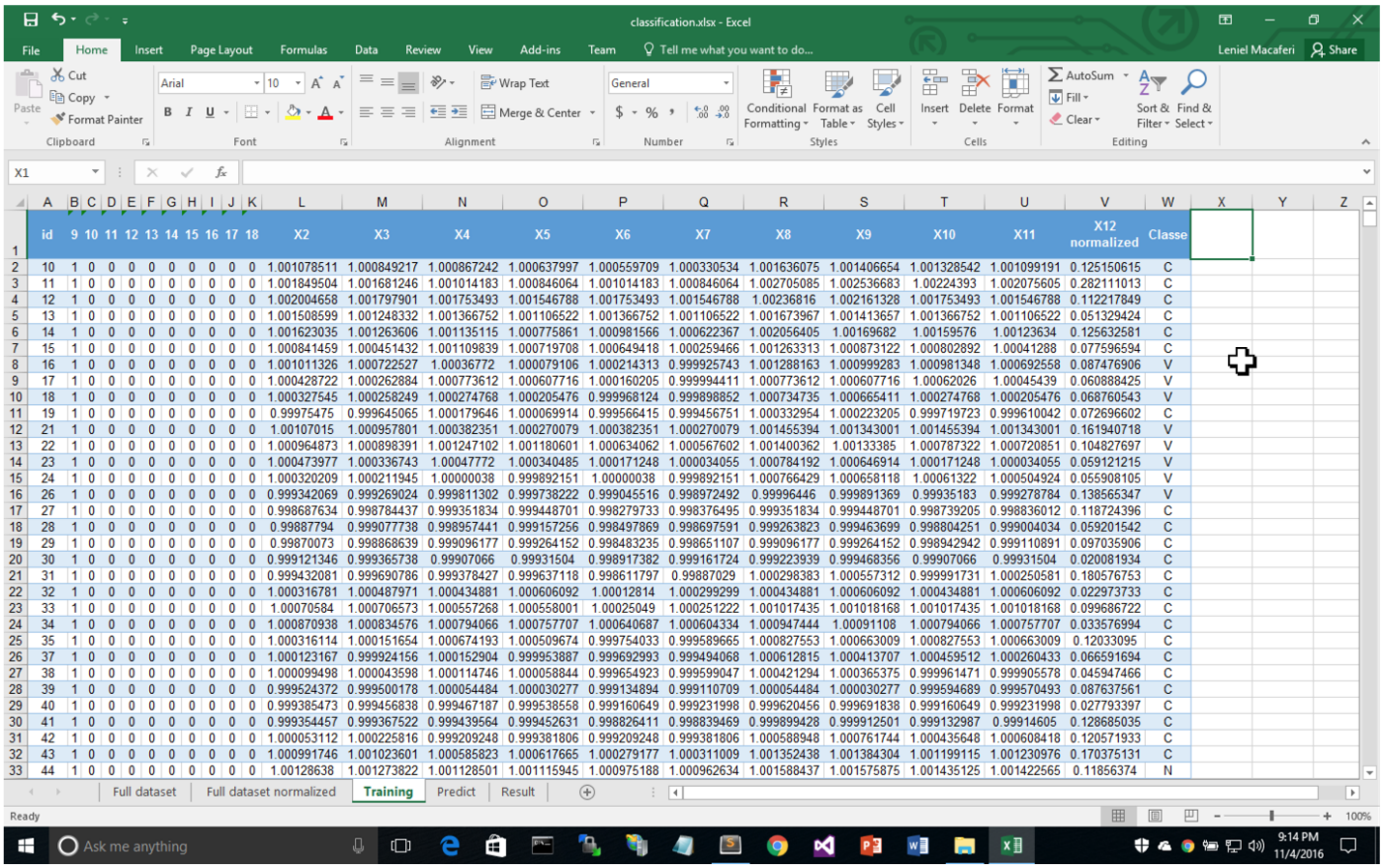
Neural Networks http://scikit-learn.org/stable/modules/neural_networks_supervised.html

Model evaluation: http://scikit-learn.org/stable/modules/model_evaluation.html

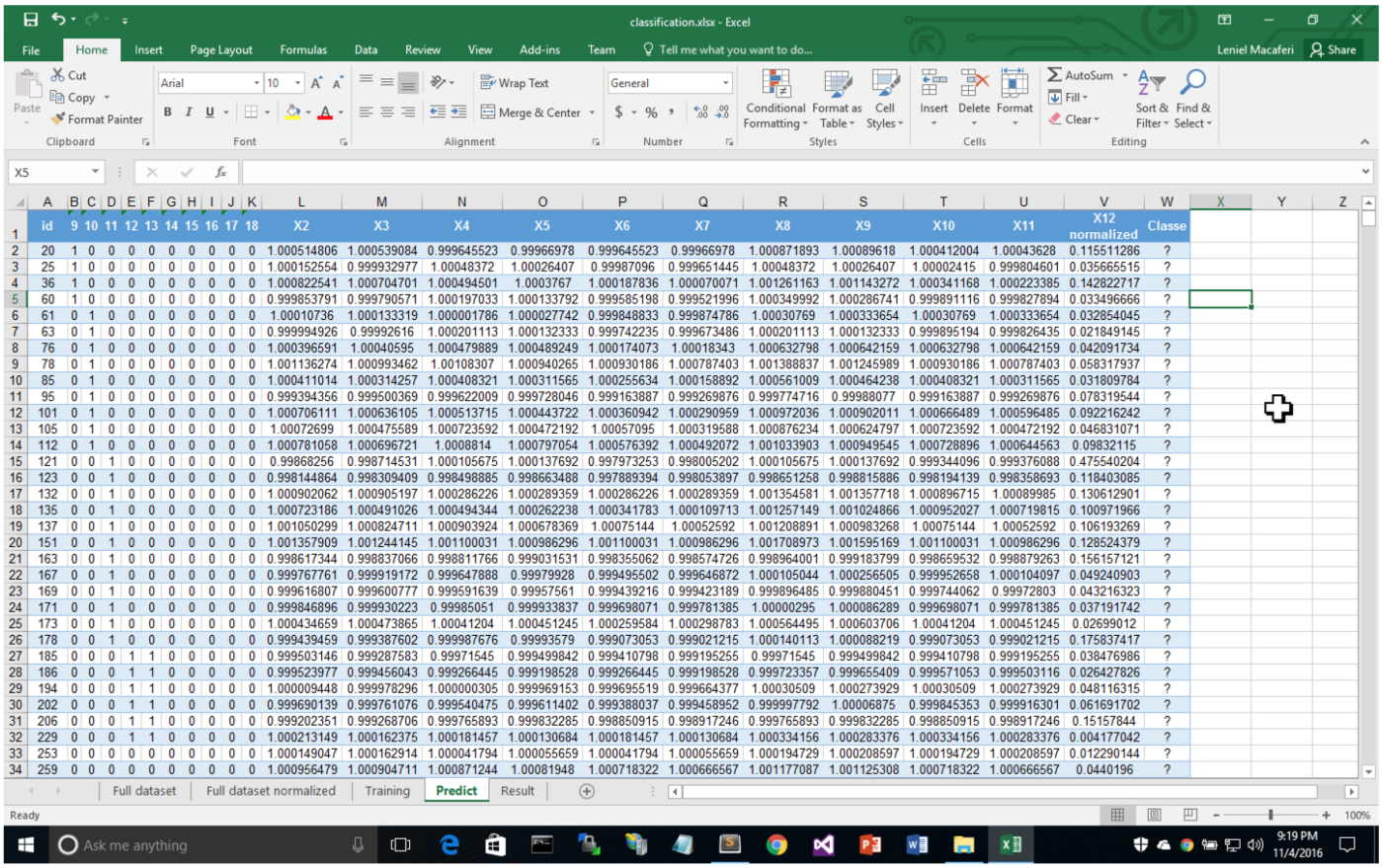
Cross-validation: evaluating estimator performance: http://scikit-learn.org/stable/modules/cross_validation.html#cross-validation

Data

The Training sheet contains the massaged data which is already labeled with classes C, N and V.



id	9	10	11	12	13	14	15	16	17	18	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12 normalized	Classe
10	1	0	0	0	0	0	0	0	0	0	1.001078511	1.000849217	1.000867242	1.000637997	1.000559709	1.000330534	1.001636075	1.001406654	1.001328542	1.001099191	0.125150615	C
11	1	0	0	0	0	0	0	0	0	0	1.001849504	1.001681246	1.001014183	1.000846064	1.001014183	1.000846064	1.002705085	1.002536683	1.00224393	1.002075605	0.282111013	C
12	1	0	0	0	0	0	0	0	0	0	1.002004658	1.001797901	1.001753493	1.001546788	1.001753493	1.001546788	1.00236816	1.002161328	1.001753493	1.001546788	0.112217849	C
13	1	0	0	0	0	0	0	0	0	0	1.001508599	1.001248332	1.001366752	1.001106522	1.001366752	1.001106522	1.001673967	1.001413657	1.001366752	1.001106522	0.051329424	C
14	1	0	0	0	0	0	0	0	0	0	1.001623035	1.001263606	1.001135115	1.000775861	1.000981566	1.000622367	1.002056405	1.00169682	1.00159576	1.00123634	0.125632581	C
15	1	0	0	0	0	0	0	0	0	0	1.000841459	1.000451432	1.001109839	1.000719708	1.000649418	1.000259466	1.001263313	1.000873122	1.000802892	1.00041288	0.077596594	C
16	1	0	0	0	0	0	0	0	0	0	1.001011326	1.000722527	1.00036772	1.000079106	1.000214313	0.999925743	1.001288163	1.000999283	1.000981348	1.000692558	0.087476906	V
17	1	0	0	0	0	0	0	0	0	0	1.000428722	1.000262884	1.000773612	1.000607716	1.000160205	0.999994411	1.000773612	1.000607716	1.00062026	1.00045439	0.060888425	V
18	1	0	0	0	0	0	0	0	0	0	1.000327545	1.000258249	1.000274768	1.000205476	0.999968124	0.999898852	1.000734735	1.000665411	1.000274768	1.000205476	0.068760543	V
19	1	0	0	0	0	0	0	0	0	0	0.99975475	0.999645065	1.000179646	1.000069914	0.999566415	0.999456751	1.000332954	1.000223205	0.999719723	0.999610042	0.072696602	C
20	1	0	0	0	0	0	0	0	0	0	1.00107015	1.000957801	1.000382351	1.000270079	1.000382351	1.000270079	1.001455394	1.001343001	1.001455394	1.001343001	0.161940718	V
21	1	0	0	0	0	0	0	0	0	0	1.000964873	1.000898391	1.001247102	1.001180601	1.000634062	1.000567602	1.001400362	1.00133385	1.000787322	1.000720851	0.104827697	V
22	1	0	0	0	0	0	0	0	0	0	1.000473977	1.000336743	1.00047772	1.000340485	1.000171248	1.000034055	1.000784192	1.000646914	1.000171248	1.000034055	0.059121215	V
23	1	0	0	0	0	0	0	0	0	0	1.000320209	1.000211945	1.00000038	0.999892151	1.00000038	0.999892151	1.000766429	1.000658118	1.00061322	1.000504924	0.055908105	V
24	1	0	0	0	0	0	0	0	0	0	0.999342069	0.999269024	0.999811302	0.999738222	0.999045516	0.998972492	0.99996446	0.999891369	0.99935183	0.999278784	0.138565347	V
25	1	0	0	0	0	0	0	0	0	0	0.998687634	0.998784437	0.999351834	0.999448701	0.998279733	0.998376495	0.999351834	0.999448701	0.998739205	0.998836012	0.118724396	C
26	1	0	0	0	0	0	0	0	0	0	0.99887794	0.999077738	0.998957441	0.999157256	0.998497869	0.998697591	0.999263823	0.999463699	0.998804251	0.999004034	0.059201542	C
27	1	0	0	0	0	0	0	0	0	0	0.99870073	0.998868639	0.999096177	0.999264152	0.998483235	0.998651107	0.999096177	0.999264152	0.998942942	0.999110891	0.097035906	C
28	1	0	0	0	0	0	0	0	0	0	0.999121346	0.999365738	0.99907066	0.99931504	0.998917382	0.999161724	0.999223939	0.999468356	0.99907066	0.99931504	0.020081934	C
29	1	0	0	0	0	0	0	0	0	0	0.999432081	0.999690786	0.999378427	0.999637118	0.998611797	0.99887029	1.000298383	1.000557312	0.999991731	1.000250581	0.180576753	C
30	1	0	0	0	0	0	0	0	0	0	1.000316781	1.000487971	1.000434881	1.000606092	1.00012814	1.000299299	1.000434881	1.000606092	1.000434881	1.000606092	0.022973733	C
31	1	0	0	0	0	0	0	0	0	0	1.00070584	1.000706573	1.000557268	1.000558001	1.00025049	1.000251222	1.001017435	1.001018168	1.001017435	1.001018168	0.099686722	C
32	1	0	0	0	0	0	0	0	0	0	1.000870938	1.000834576	1.000794066	1.000757707	1.000640687	1.000604334	1.000947444	1.00091108	1.000794066	1.000757707	0.033576994	C
33	1	0	0	0	0	0	0	0	0	0	1.000316114	1.000151654	1.000674193	1.000509674	0.999754033	0.999589665	1.000827553	1.000663009	1.000827553	1.000663009	0.12033095	C
35	1	0	0	0	0	0	0	0	0	0	1.000123167	0.999924156	1.000152904	0.999953887	0.999692993	0.999494068	1.000612815	1.000413707	1.000459512	1.000260433	0.066591694	C
37	1	0	0	0	0	0	0	0	0	0	1.000099498	1.000043598	1.000114746	1.000058844	0.999654923	0.999599047	1.000421294	1.000365375	0.999961471	0.999905578	0.045947466	C
38	1	0	0	0	0	0	0	0	0	0	0.999524372	0.999500178	1.000054484	1.000030277	0.999134894	0.999110709	1.000054484	1.000030277	0.999594689	0.999570493	0.087637561	C
39	1	0	0	0	0	0	0	0	0	0	0.999385473	0.999456838	0.999467187	0.999538558	0.999160649	0.999231998	0.999620456	0.999691838	0.999160649	0.999231998	0.027793397	C
40	1	0	0	0	0	0	0	0	0	0	0.999354457	0.999367522	0.999439564	0.999452631	0.998826411	0.998839469	0.999899428	0.999912501	0.999132987	0.99914605	0.128685035	C
41	1	0	0	0	0	0	0	0	0	0	1.000053112	1.000225816	0.999209248	0.999381806	0.999209248	0.999381806	1.000588948	1.000761744	1.000435648	1.000608418	0.120571933	C
42	1	0	0	0	0	0	0	0	0	0	1.000991746	1.001023601	1.000585823	1.000617665	1.000279177	1.000311009	1.001352438	1.001384304	1.001199115	1.001230976	0.170375131	C
43	1	0	0	0	0	0	0	0	0	0	1.00128638	1.001273822	1.001128501	1.001115945	1.000975188	1.000962634	1.001588437	1.001575875	1.001435125	1.001422565	0.11856374	N
44	1	0	0	0	0	0	0	0	0	0												



id	9	10	11	12	13	14	15	16	17	18	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12 normalized	Classe
20	1	0	0	0	0	0	0	0	0	0	1.000514806	1.000539084	0.999645523	0.99966978	0.999645523	0.99966978	1.000871893	1.00089618	1.000412004	1.00043628	0.115511286	?
25	1	0	0	0	0	0	0	0	0	0	1.000152554	0.999932977	1.00048372	1.00026407	0.99987096	0.999651445	1.00048372	1.00026407	1.00002415	0.999804601	0.035665515	?
36	1	0	0	0	0	0	0	0	0	0	1.000822541	1.000704701	1.000494501	1.0003767	1.000187836	1.000070071	1.001261163	1.001143272	1.000341168	1.000223385	0.142822717	?
60	1	0	0	0	0	0	0	0	0	0	0.999853791	0.999790571	1.000197033	1.000133792	0.999585198	0.999521996	1.000349992	1.000286741	0.999891116	0.999827894	0.033496666	?
61	0	1	0	0	0	0	0	0	0	0	1.00010736	1.000133319	1.000001786	1.000027742	0.999848833	0.999874786	1.00030769	1.000333654	1.00030769	1.000333654	0.032854045	?
63	0	1	0	0	0	0	0	0	0	0	0.999994926	0.99992616	1.000201113	1.000132333	0.999742235	0.999673486	1.000201113	1.000132333	0.999895194	0.999826435	0.021849145	?
76	0	1	0	0	0	0	0	0	0	0	1.000396591	1.00040595	1.000479889	1.000489249	1.000174073	1.00018343	1.000632798	1.000642159	1.000632798	1.000642159	0.042091734	?
78	0	1	0	0	0	0	0	0	0	0	1.001136274	1.000993462	1.00108307	1.000940265	1.000930186	1.000787403	1.001388837	1.001245989	1.000930186	1.000787403	0.058317937	?
85	0	1	0	0	0	0	0	0	0	0	1.000411014	1.000314257	1.000408321	1.000311565	1.000255634	1.000158892	1.000561009	1.000464238	1.000408321	1.000311565	0.031809784	?
95	0	1	0	0	0	0	0	0	0	0	0.999394356	0.999500369	0.999622009	0.999728046	0.999163887	0.999269876	0.999774716	0.99988077	0.999163887	0.999269876	0.078319544	?
101	0	1	0	0	0	0	0	0	0	0	1.000706111	1.000636105	1.000513715	1.000443722	1.000360942	1.000290959	1.000972036	1.000902011	1.000666489	1.000596485	0.092216242	?
105	0	1	0	0	0	0	0	0	0	0	1.00072699	1.000475589	1.000723592	1.000472192	1.00057095	1.000319588	1.000876234	1.000624797	1.000723592	1.000472192	0.046831071	?
112	0	1	0	0	0	0	0	0	0	0	1.000781058	1.000696721	1.0008814	1.000797054	1.000576392	1.000492072	1.001033903	1.000949545	1.000728896	1.000644563	0.09832115	?
121	0	0	1	0	0	0	0	0	0	0	0.99868256	0.998714531	1.000105675	1.000137692	0.997973253	0.998005202	1.000105675	1.000137692	0.999344096	0.999376088	0.475540204	?
123	0	0	1	0	0	0	0	0	0	0	0.998144864	0.998309409	0.998498885	0.998663488	0.997889394	0.998053897	0.998651258	0.998815886	0.998194139	0.998358693	0.118403085	?
132	0	0	1	0	0	0	0	0	0	0	1.000902062	1.000905197	1.000286226	1.000289359	1.000286226	1.000289359	1.001354581	1.001357718	1.000896715	1.00089985	0.130612901	?
135	0	0	1	0	0	0	0	0	0	0	1.000723186	1.000491026	1.000494344	1.000262238	1.000341783	1.000109713	1.001257149	1.001024866	1.000952027	1.000719815	0.100971966	?
137	0	0	1	0	0	0	0	0	0	0	1.001050299	1.000824711	1.000903924	1.000678369	1.00075144	1.00052592	1.001208891	1.000983268	1.00075144	1.00052592	0.106193269	?
151	0	0	1	0	0	0	0	0	0	0	1.001357909	1.001244145	1.001100031	1.000986296	1.001100031	1.000986296	1.001708973	1.001595169	1.001100031	1.000986296	0.128524379	?
163	0	0	1	0	0	0	0	0	0	0	0.998617344	0.998837066	0.998811766	0.999031531	0.998355062	0.998574726	0.998964001	0.999183799	0.998659532	0.998879263	0.156157121	?
167	0	0	1	0	0	0	0	0	0	0	0.999767761	0.999919172	0.999647888	0.99979928	0.999495502	0.999646872	1.000105044	1.000256505	0.999952658	1.000104097	0.049240903	?
169	0	0	1	0	0	0	0	0	0	0	0.999616807	0.999600777	0.999591639	0.99957561	0.999439216	0.999423189	0.999896485	0.999880451	0.999744062	0.99972803	0.043216323	?
171	0	0	1	0	0	0	0	0	0	0	0.999846896	0.999930223	0.99985051	0.999933837	0.999698071	0.999781385	1.00000295	1.000086289	0.999698071	0.999781385	0.037191742	?
173	0	0	1	0	0	0	0	0	0	0	1.000434659	1.000473865	1.00041204	1.000451245	1.000259584	1.000298783	1.000564495	1.000603706	1.00041204	1.000451245	0.02699012	?
178	0	0	1	0	0	0	0	0	0	0	0.999439459	0.999387602	0.999987676	0.99993579	0.999073053	0.999021215	1.000140113	1.000088219	0.999073053	0.999021215	0.175837417	?
185	0	0	0	1	1	0	0	0	0	0	0.999503146	0.999287583	0.99971545	0.999499842	0.999410798	0.999195255	0.99971545	0.999499842	0.999410798	0.999195255	0.038476986	?
186	0	0	0	1	1	0	0	0	0	0	0.999523977	0.999456043	0.999266445	0.999198528	0.999266445	0.999198528	0.999723357	0.999655409	0.999571053	0.999503116	0.026427826	?
194	0	0	0	1	1	0	0	0	0	0	1.000009448	0.999978296	1.000000305	0.999969153	0.999695519	0.999664377	1.00030509	1.000273929	1.00030509	1.000273929	0.048116315	?
202	0	0	0	1	1	0	0	0	0	0	0.999690139	0.999761076	0.999540475	0.999611402	0.999388037	0.999458952	0.999997792	1.00006875	0.999845353	0.999916301	0.061691702	?
206	0	0	0	1	1	0	0	0	0	0	0.999202351	0.999268706	0.999765893	0.999832285	0.998850915	0.998917246	0.999765893	0.999832285	0.998850915	0.998917246	0.15157844	?
229	0	0	0	1	1	0	0	0	0	0	1.000213149	1.000162375	1.000181457	1.000130684	1.000181457	1.000130684	1.000334156	1.000283376	1.000334156	1.000283376	0.004177042	?
253	0	0	0	0	0	0	0	0	0	0	1.000149047	1.000162914	1.000041794	1.000055659	1.000041794	1.000055659	1.000194729	1.000208597	1.000194729	1.000208597	0.012290144	?
259	0	0	0	0	0	0	0	0	0	0	1.000956479	1.000904711	1.000871244	1.00081948	1.000718322	1.000666567	1.001177087	1.001125308	1.000718322	1.000666567	0.0440196	?

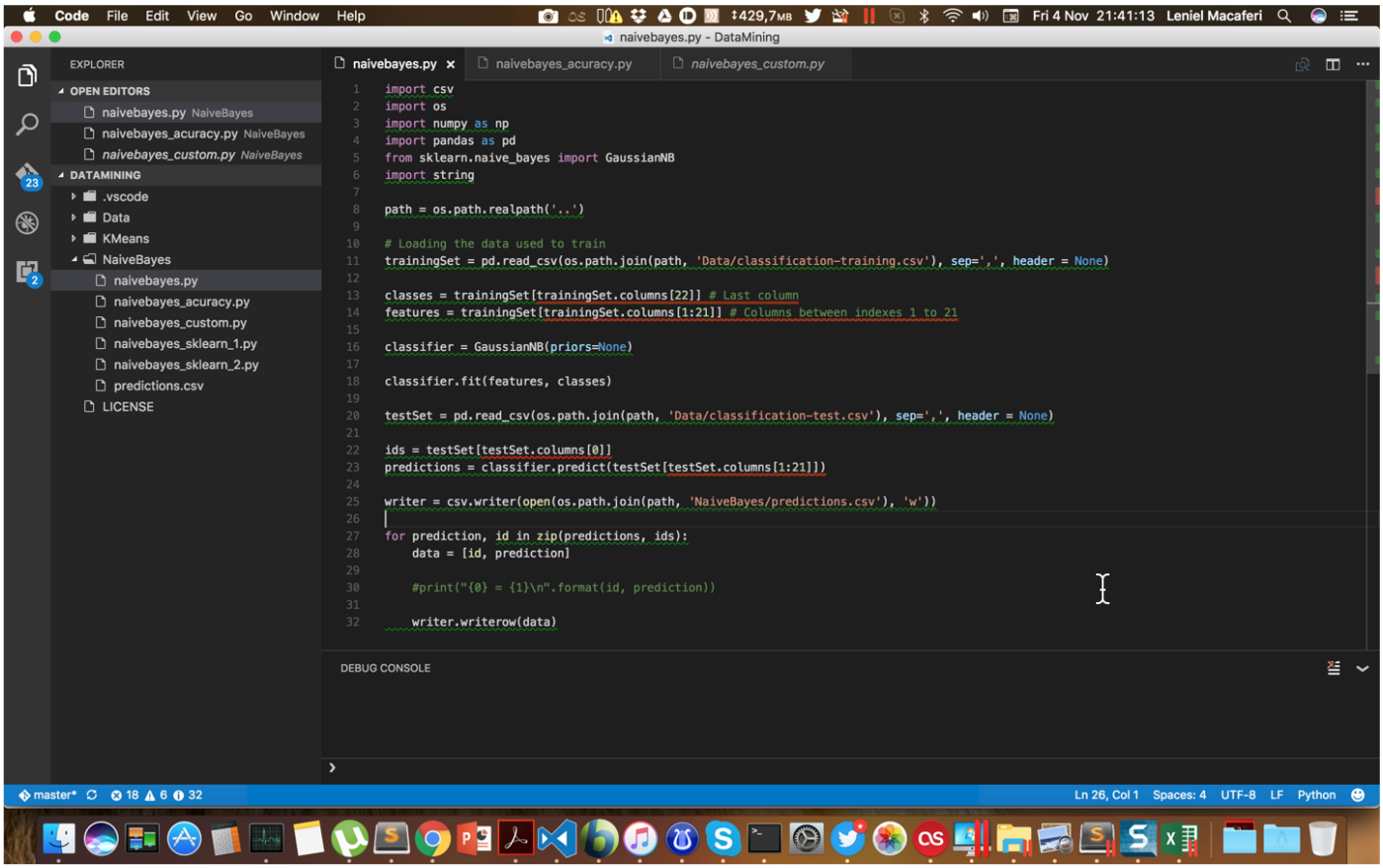
The Test sheet contains the massaged data which is unclassified ?.

The data in Excel XLSX file was saved in the CSV file format to serve as input to the Python source code.

Two files were created:

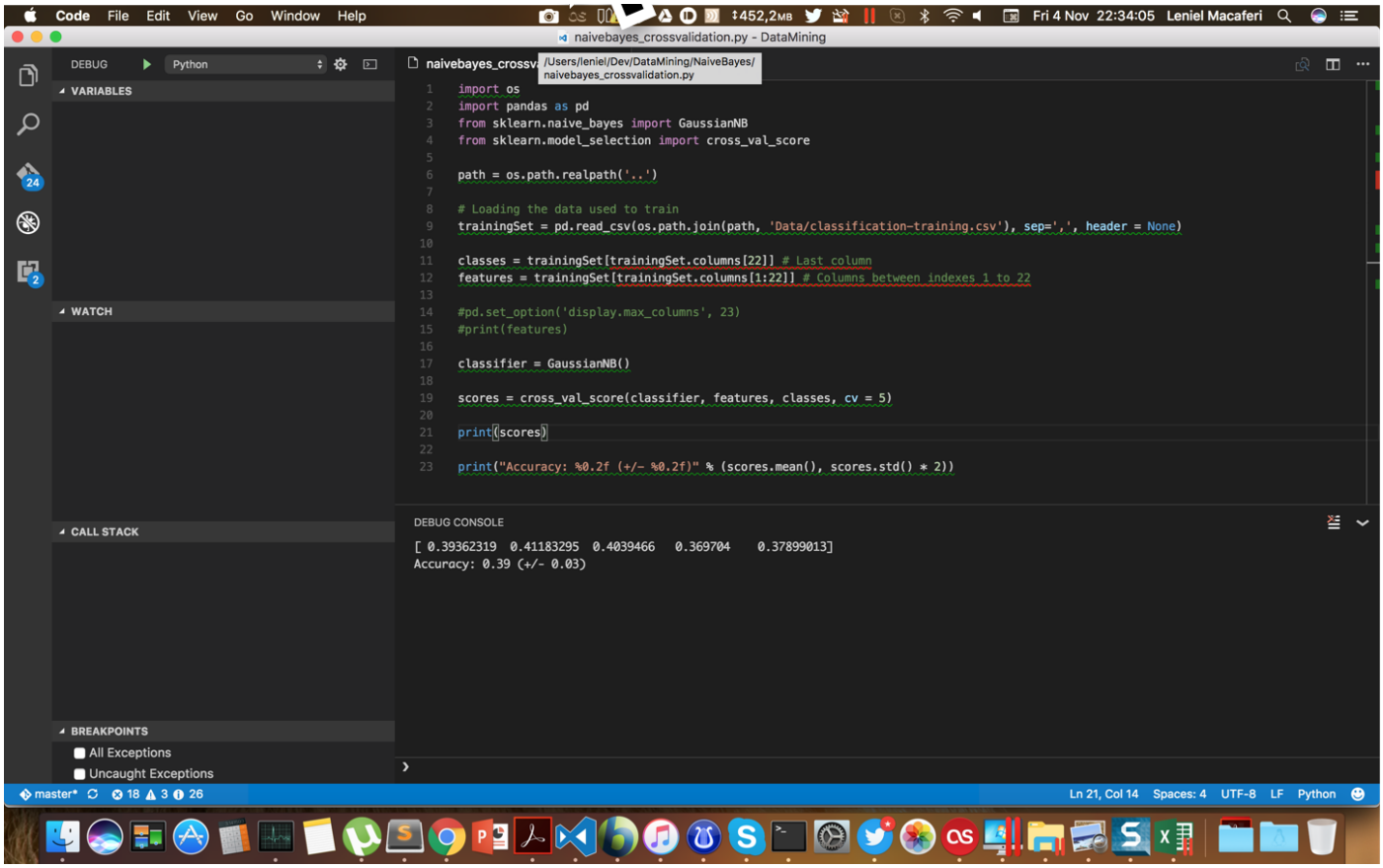
- classification-training.csv [including the sample data already classified]
- classification-test.csv [including the sample data unclassified]

Naive Bayes



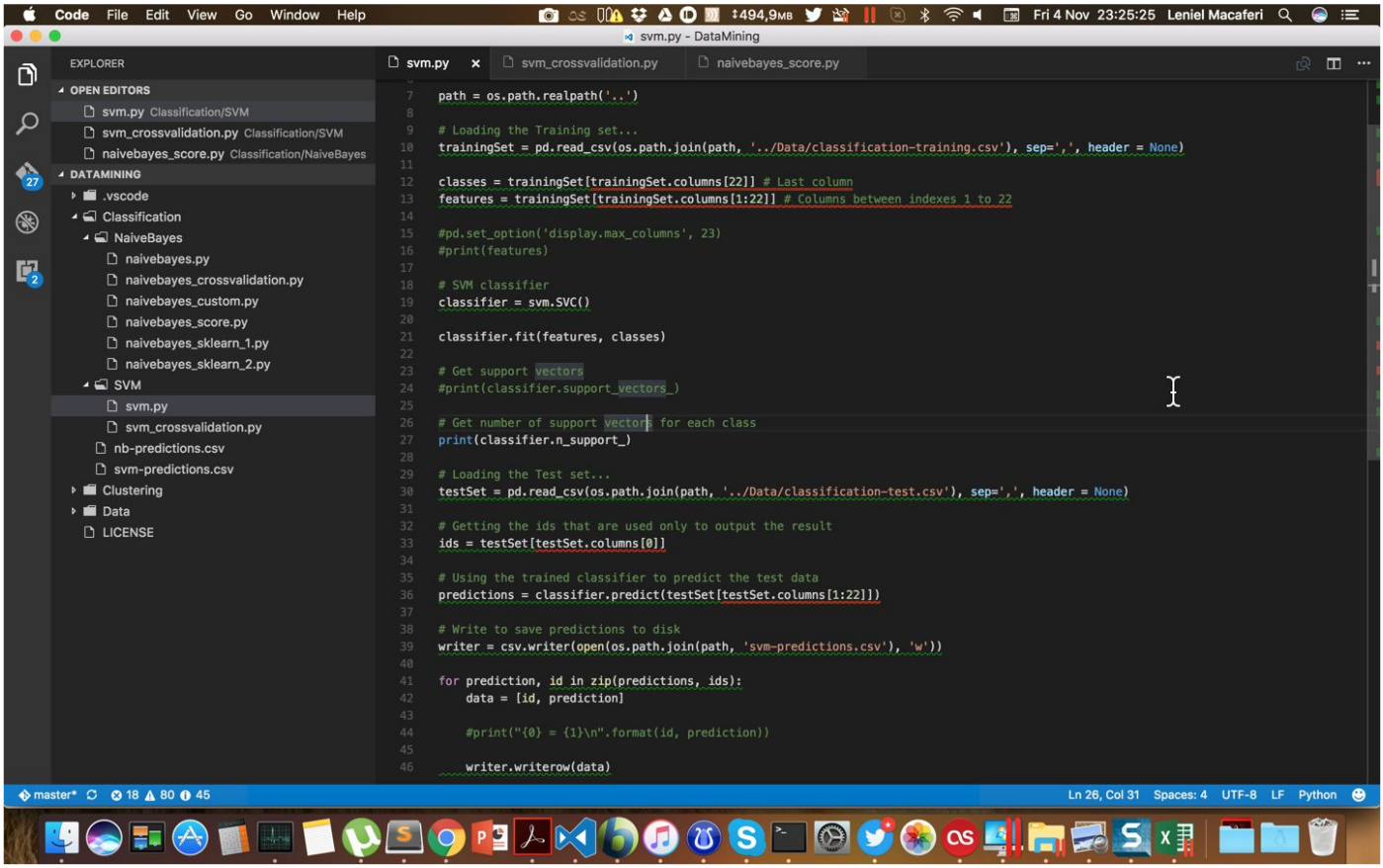

```python
import csv
import os
import numpy as np
import pandas as pd
from sklearn.naive_bayes import GaussianNB
import string

path = os.path.realpath('..')

# Loading the data used to train
trainingSet = pd.read_csv(os.path.join(path, 'Data/classification-training.csv'), sep=',', header = None)

classes = trainingSet[trainingSet.columns[22]] # Last column
features = trainingSet[trainingSet.columns[1:21]] # Columns between indexes 1 to 21

classifier = GaussianNB(priors=None)

classifier.fit(features, classes)

testSet = pd.read_csv(os.path.join(path, 'Data/classification-test.csv'), sep=',', header = None)

ids = testSet[testSet.columns[0]]
predictions = classifier.predict(testSet[testSet.columns[1:21]])

writer = csv.writer(open(os.path.join(path, 'NaiveBayes/predictions.csv'), 'w'))

for prediction, id in zip(predictions, ids):
    data = [id, prediction]

    #print("{0} = {1}\n".format(id, prediction))

    writer.writerow(data)
```

The resulting predictions are saved to an external .CSV file named nb-predictions.csv.

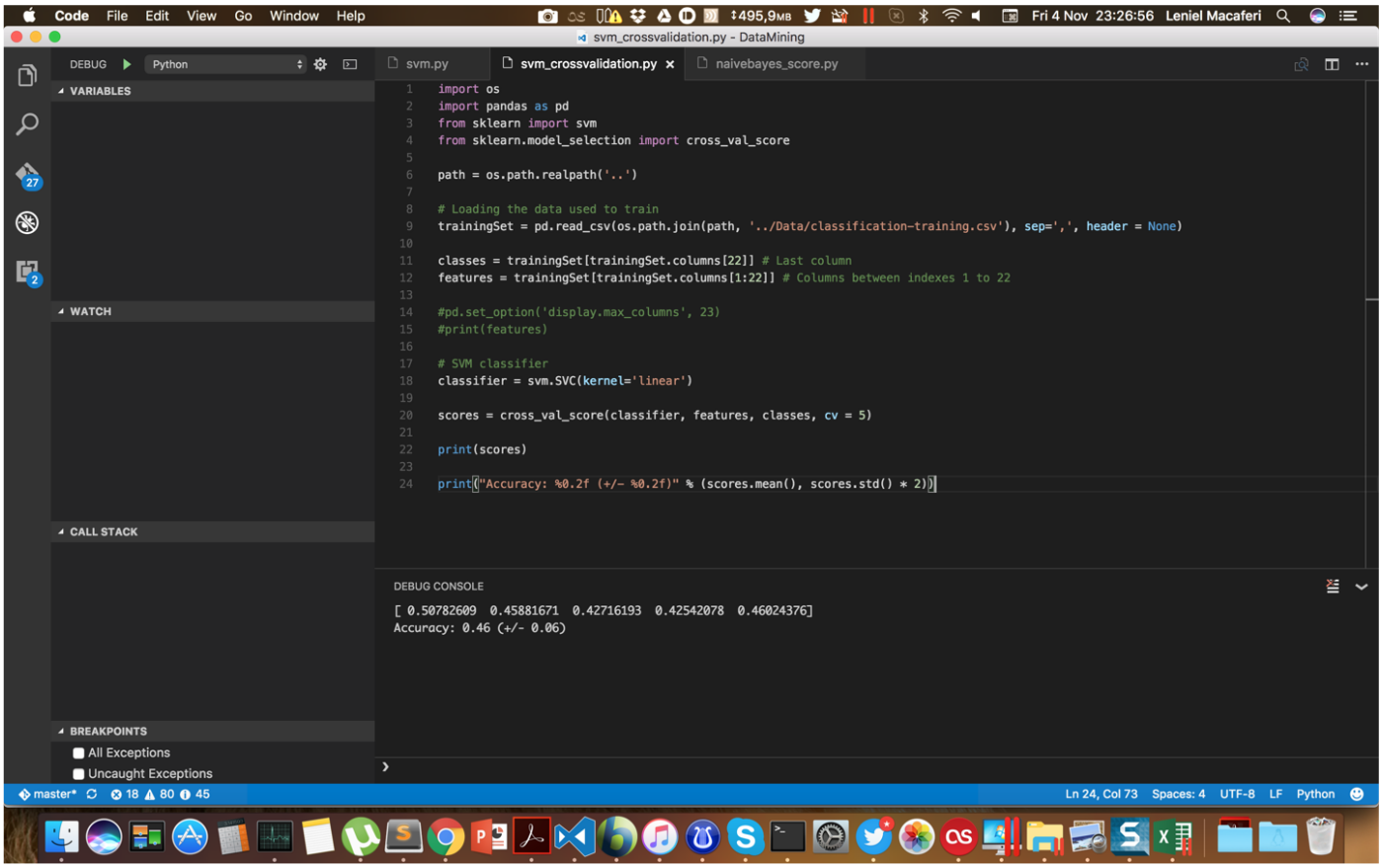


Accuracy with 5 fold validation = 0.39

SVM - Support Vector Machines

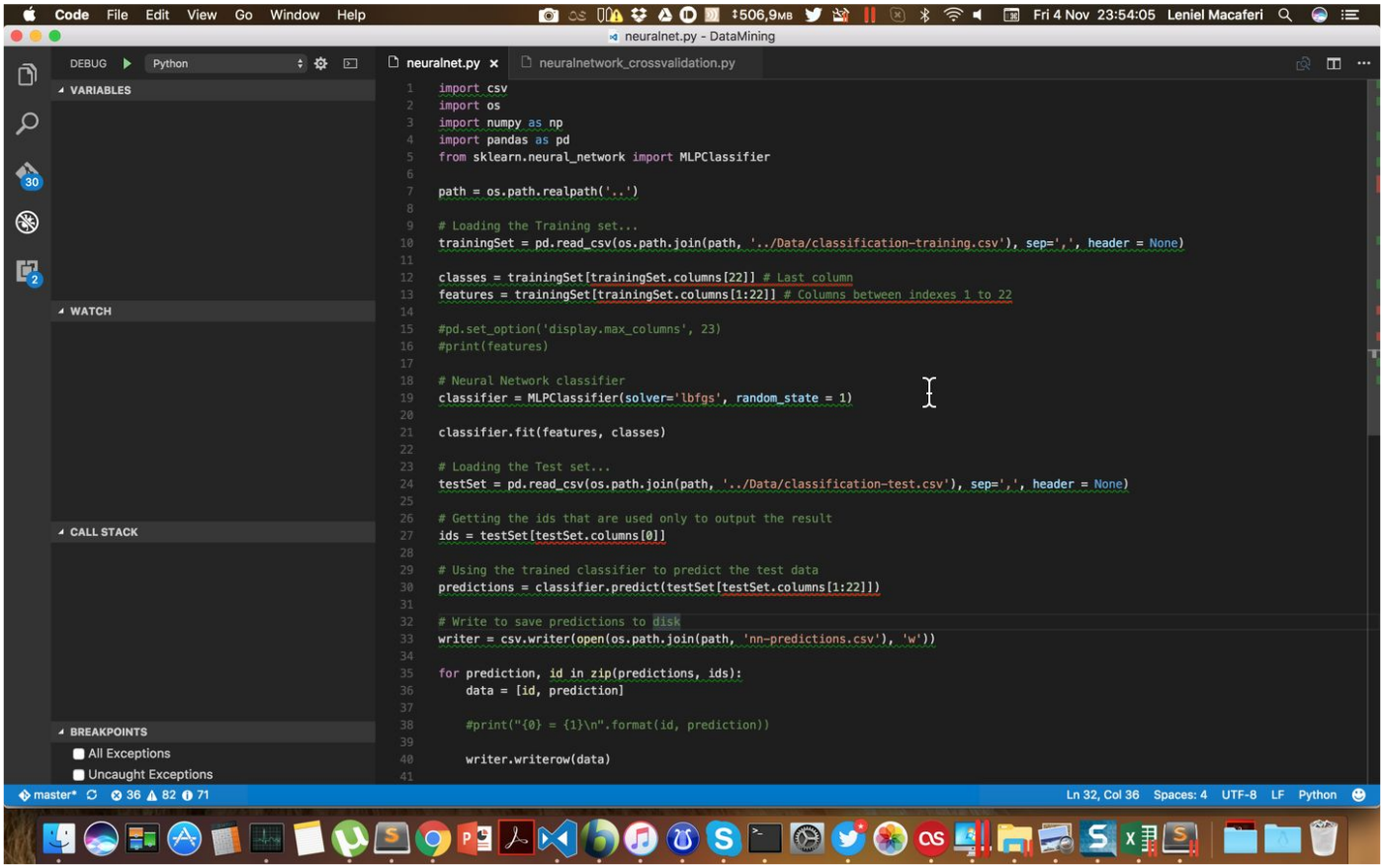


The resulting predictions are saved to an external .CSV file named svm-predictions.csv.

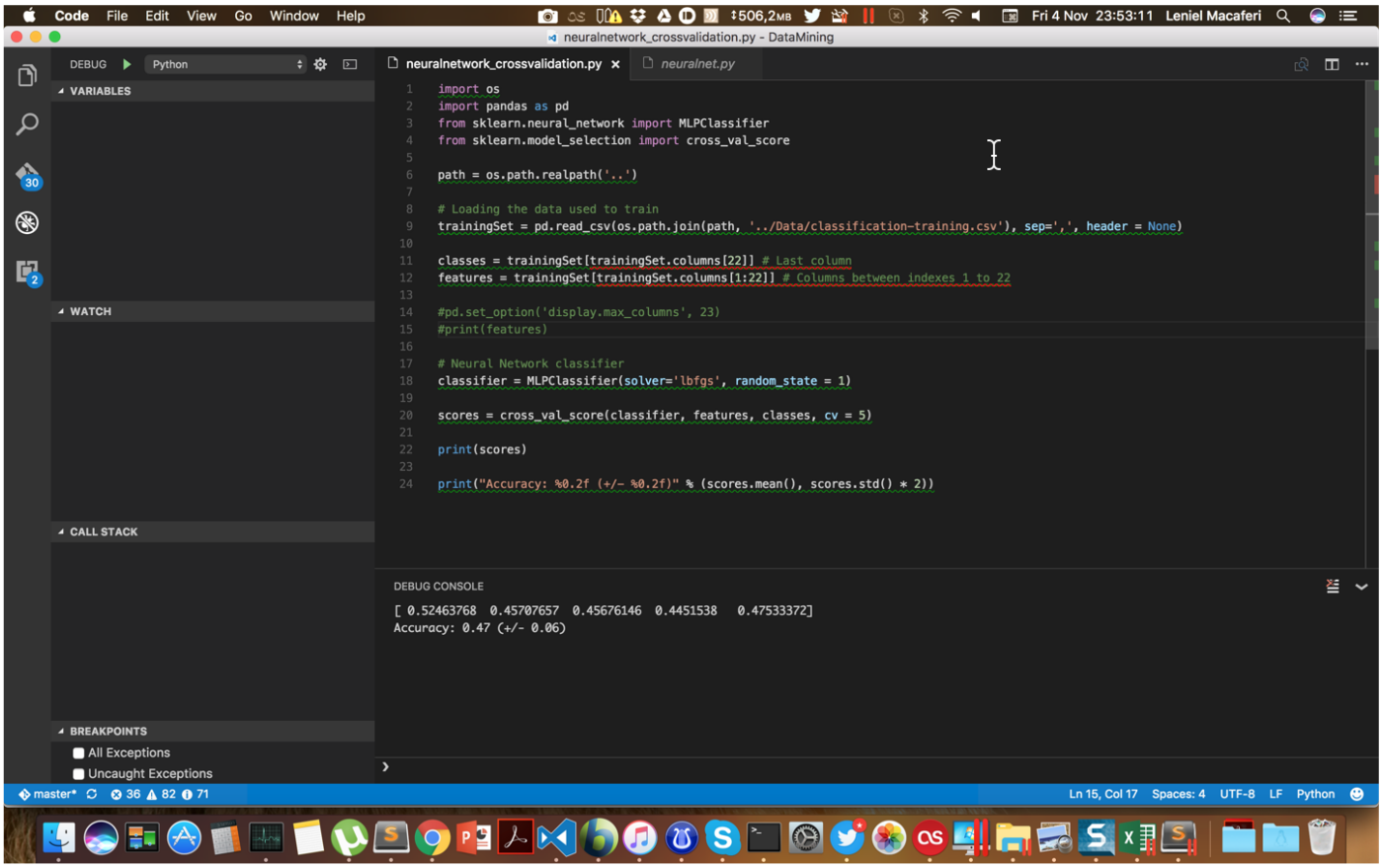


Accuracy with 5 fold validation = 0.46

Neural Network



The resulting predictions are saved to an external .CSV file named nn-predictions.csv.

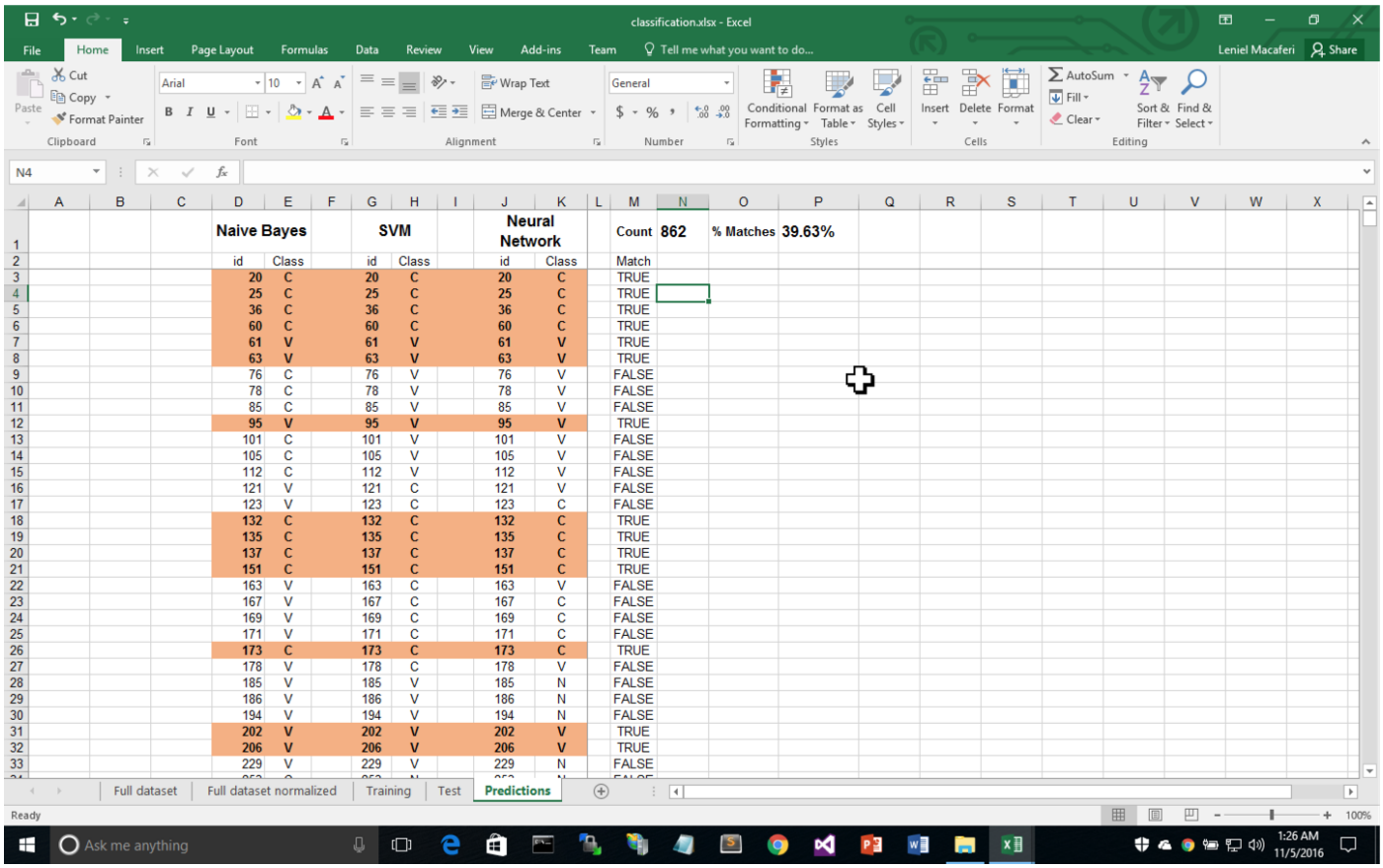


Accuracy with 5 fold validation = 0.47

Analysis

The spreadsheet is available @
https://github.com/leniel/DataMining/blob/master/Data/classification.xlsx

The Predictions sheet lists all output from the classifiers:



	Naive Bayes		SVM		Neural Network		Count	862	% Matches	39.63%
	id	Class	id	Class	id	Class	Match			
3	20	C	20	C	20	C	TRUE			
4	25	C	25	C	25	C	TRUE			
5	36	C	36	C	36	C	TRUE			
6	60	C	60	C	60	C	TRUE			
7	61	V	61	V	61	V	TRUE			
8	63	V	63	V	63	V	TRUE			
9	76	C	76	V	76	V	FALSE			
10	78	C	78	V	78	V	FALSE			
11	85	C	85	V	85	V	FALSE			
12	95	V	95	V	95	V	TRUE			
13	101	C	101	V	101	V	FALSE			
14	105	C	105	V	105	V	FALSE			
15	112	C	112	V	112	V	FALSE			
16	121	V	121	C	121	V	FALSE			
17	123	V	123	C	123	C	FALSE			
18	132	C	132	C	132	C	TRUE			
19	135	C	135	C	135	C	TRUE			
20	137	C	137	C	137	C	TRUE			
21	151	C	151	C	151	C	TRUE			
22	163	V	163	C	163	V	FALSE			
23	167	V	167	C	167	C	FALSE			
24	169	V	169	C	169	C	FALSE			
25	171	V	171	C	171	C	FALSE			
26	173	C	173	C	173	C	TRUE			
27	178	V	178	C	178	V	FALSE			
28	185	V	185	V	185	N	FALSE			
29	186	V	186	V	186	N	FALSE			
30	194	V	194	V	194	N	FALSE			
31	202	V	202	V	202	V	TRUE			
32	206	V	206	V	206	V	TRUE			
33	229	V	229	V	229	N	FALSE			

Out of 2175 unclassified samples, 862 matched in all classifiers experimented. That's 39.63% of samples.