Unsupervised Capstone:

Classify authors based on the style of text

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Problem Statement

- Build an unsupervised model that will classify authors based on the style of writing using natural language processing.

Research Questions:

- Are authors consistently grouped into the same cluster?
- Does your clustering on those members perform as you'd expect?
- Have your clusters remained stable or changed dramatically?
- Does our model provide a consistent performance?

Solution statement

- Import data from ten different authors of various writing styles
- Clean, tokenize and lemmatize the data
- Generate features using TFIDF
- Generate clusters (i.e. K-mean, MeanShift…etc.)
- Evaluate the performance of the clusters
- Generate models (i.e. Random Forest, logistic…etc.)
- Evaluate the performance of the models

Evaluation metrics of clusters and models

- Utilize the RI adjusted score to evaluate the performance of each clusters.
- Use confusion matrix, classification report and accuracy score to evaluate the performance of each model.

Analysis – input of raw text file

Example of raw text file – Macbeth

"[The Tragedie of Macbeth by William Shakespeare 1603]\n\n\nActus Primus. Scoena Prima.\n\n
Thunder and Lightning. Enter three Witches.\n\n 1. When shall we three meet againe?\nIn Th
under, Lightning, or in Raine?\n 2. When the Hurley-burley's done,\nWhen the Battaile's lo
st, and wonne\n\n   3. That will be ere the set of Sunne\n\n   1. Where the place?\n 2. Vp
on the Heath\n\n   3. There to meet with Macbeth\n\n   1. I come, Gray-Malkin\n\n   All. Pa
dock calls anon: faire is foule, and foule is faire,\nHouer through the fogge and filthie a
yre.\n\nExeunt.\n\n\nScena Secunda.\n\nAlarum within. Enter King Malcome, Donalbaine, Lenox
, with\nattendants,\nmeeting a bleeding Captaine.\n\n King. What bloody man is that? he ca
n report,\nAs seemeth by his plight, of the Reuolt\nThe newest state\n\n   Mal. This is the
Serieant,\nWho like a good and hardie Souldier fought\n'Gainst my Captiuitie: Haile braue f
riend;\nSay to the King, the knowledge of the Broyle,\nAs thou didst leaue it\n\n   Cap. Do
ubtfull it stood,\nAs two spent Swimmers, that doe cling together,\nAnd choake their Art: T
he mercilesse Macdonwald\n(Worthie to be a Rebell, for to that\nThe multiplying Villanies o
f Nature\nDoe swarme vpon him) from the Westerne Isles\nOf Kernes and Gallowgrosses is supp
ly'd,\nAnd Fortune on his damned Quarry smiling,\nShew'd like a Rebells Whore: but all's to
o weake:\nFor braue Macbeth (well hee deserues that Name)\nDisdayning Fortune, with his bra
ndisht Steele,\nWhich smoak'd with bloody execution\n(Like Valours Minion) caru'd out his p
assage,\nTill hee fac'd the Slaue:\nWhich neu'r shooke hands, nor bad farwell to him,\nTill
he vnseam'd him from the Naue toth' Chops,\nAnd fix'd his Head vpon our Battlements\n\n   K

Analysis – Text file cleaned, lemmatized and tokenized

Example of a cleaned, lemmatized and tokenized file - Macbeth

['Actus Primus Scoena Prima Thunder and Lightning Enter three Witches 1 When shall we three meet againe In Thunder Lightning or in Raine 2 When the Hurleyburleys done When the Battailes lost and wonne 3 That will be ere the set of Sunne 1 Where the place 2 Vpon the Heath 3 There to meet with Macbeth 1 I come GrayMalkin All Padock call anon faire is foule and foule is faire Houer through the fogge and filthie ayre Exeunt Scena Secunda Alarum within Enter King Malcome Donalbaine Lenox with attendant meeting a bleeding Captaine King What bloody man is that he can report As seemeth by his plight of the Reuolt The newest state Mal This is the Serieant Who like a good and hardie Souldier fought Gainst my Captiuitie Haile braue friend Say to the King the knowledge of the Broyle As thou didst leaue it Cap Doubtfull it stood As two spent Swimmers that doe cling together And choake their Art The mercilesse Macdonwald Worthie to be a Rebell for to that The multiplying Villanies of Nature Doe swarme vpon him from the Westerne Isles Of Kernes and Gallowgrosses is supplyd And Fortune on his damned Quarry smiling Shewd like a Rebells Whore but alls too weake For braue Macbeth well hee deserues that Name Disdayning Fortune with his brandisht Steele Which smoakd with bloody execution Like Valours Minion carud out his passage Till hee facd the Slaue Which neur shooke hand nor bad farwell to him Till he vnseamd him from the Naue toth Chops And fixd his Head vpon our Battlements King O valiant Cousin worthy Gentleman Cap As whence the Sunne gin

Analysis - combined document text, author and author code into a data frame.

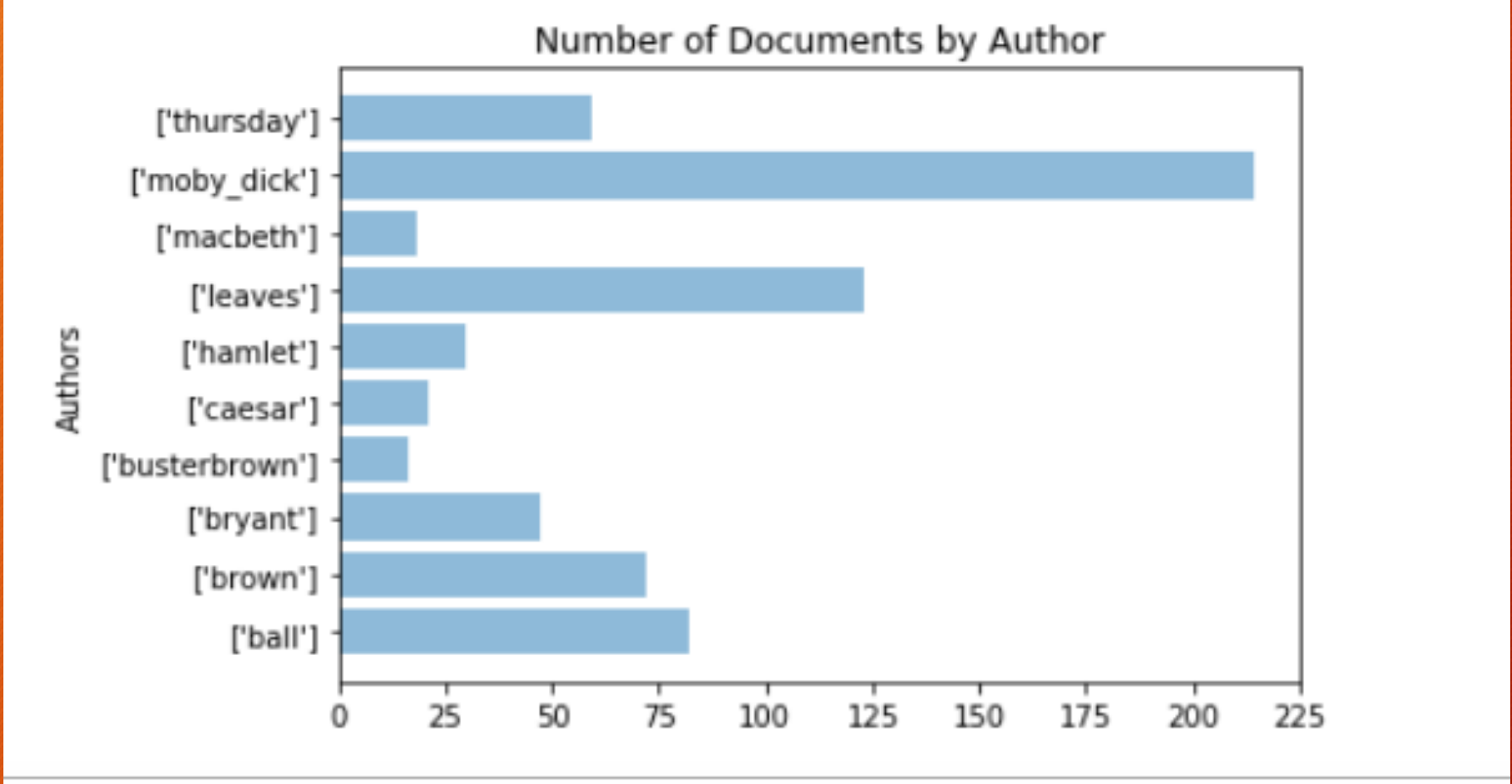
	text	authors	author_codes
0	Actus Primus Scoena Prima Enter Flauius Murell...	caesar	4
1	Forgets the shewes of Loue to other men Cassi ...	caesar	4
2	would not so with loue I might intreat you Be ...	caesar	4
3	tell you that Ile nere looke you ith face agai...	caesar	4
4	is for Romans now Haue Thewes and Limbes like ...	caesar	4

Analysis – display number of documents group by author codes and authors.

author_codes	authors	
0	ball	82
1	brown	72
2	bryant	47
3	busterbrown	16
4	caesar	21
5	hamlet	30
6	leaves	123
7	macbeth	18
8	moby_dick	214
9	thursday	59

Name: authors, dtype: int64

Analysis –visual bar chart displaying number of documents group by authors



Analysis – Feature generation of text file

Generate features using TFIDF

	10	11	12	13	14	15	16	17	18	1839	19	20	21	30	40	45	50	90	_had_	_he_	_page	_so_	_the	_
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

5 rows x 12088 columns

aft	afternoon	afterward	afterwards	againe	age	aged	agency	agent	ages	aggregate	aggressively	aghast
0.0	0.0	0.0	0.0	0.054285	0.000000	0.0	0.0	0.0	0.000000	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.000000	0.043882	0.0	0.0	0.0	0.037331	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.076387	0.000000	0.0	0.0	0.0	0.000000	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.028867	0.000000	0.0	0.0	0.0	0.000000	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.000000	0.000000	0.0	0.0	0.0	0.000000	0.0	0.0	0.0

woods	woof	wool	woollen	word	wordless	words	wore	work	workd	worke	worked	worker	working	working
0.0	0.0	0.0	0.0	0.000000	0.0	0.0	0.0	0.0	0.0	0.031282	0.0	0.0	0.0	
0.0	0.0	0.0	0.0	0.013771	0.0	0.0	0.0	0.0	0.0	0.034234	0.0	0.0	0.0	
0.0	0.0	0.0	0.0	0.023609	0.0	0.0	0.0	0.0	0.0	0.000000	0.0	0.0	0.0	
0.0	0.0	0.0	0.0	0.026765	0.0	0.0	0.0	0.0	0.0	0.000000	0.0	0.0	0.0	
0.0	0.0	0.0	0.0	0.000000	0.0	0.0	0.0	0.0	0.0	0.033973	0.0	0.0	0.0	

Cluster analysis – Top terms identified for each KNN cluster and Author code

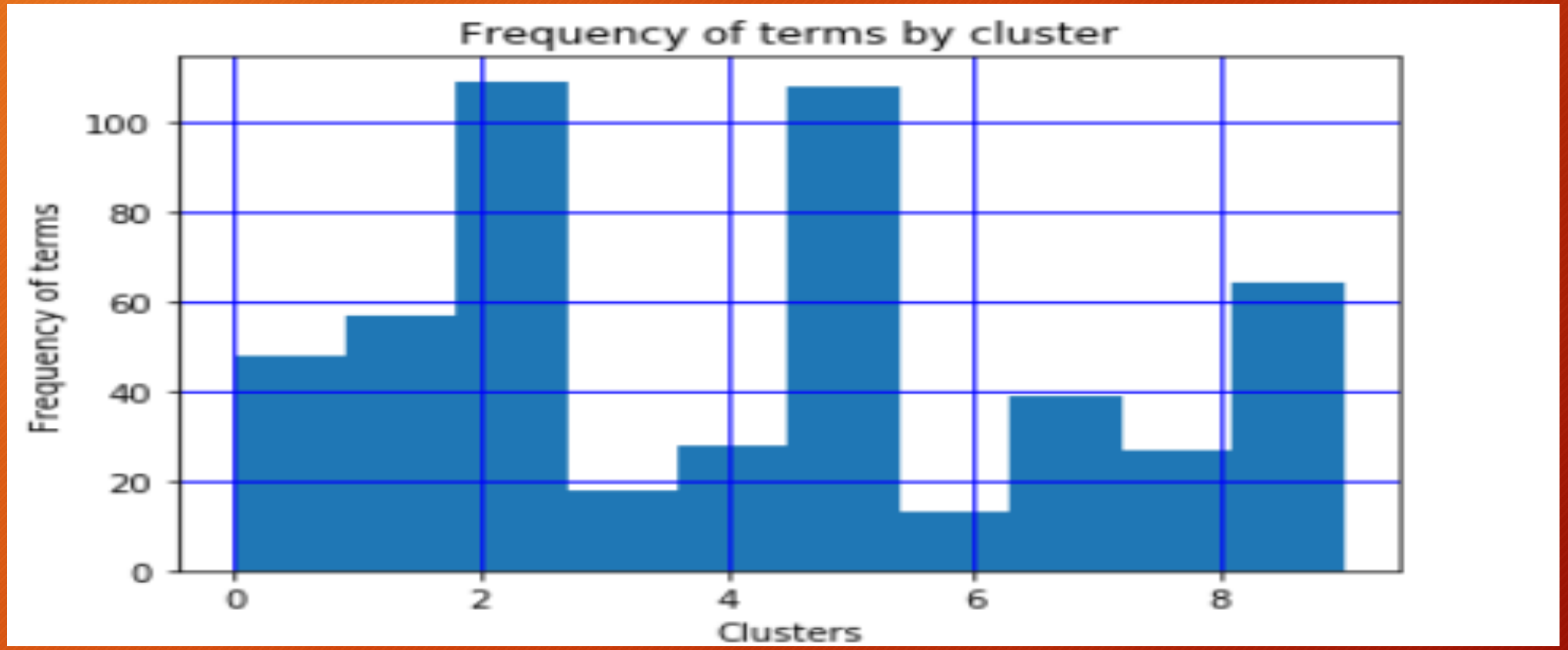
Top terms per cluster:

Cluster 0:	Cluster 1:	Cluster 2:	Cluster 3:	Cluster 4:	Cluster 5:
Authour code: 6	Authour code: 7	Authour code: 6	Authour code: 8	Authour code: 8	Authour code: 6
buster	brown	turnbull	ye	ham	syme
joe	father	macian	queequeg	haue	gregory
bear	flambeau	evan	ahab	lord	professor
browns	garden	quite	captain	macb	bull
farmer	margery	wall	ship	king	sunday
otter	priest	sword	thou	enter	marquis
blacky	door	god	starbuck	thou	dr
pool	prince	mean	sea	hor	secretary
trout	looked	garden	whale	hamlet	anarchist
boy	boulnois	really	aye	vpon	colonel

Cluster 6:	Cluster 7:	Cluster 8:	Cluster 9:
Authour code: 9	Authour code: 6	Authour code: 2	Authour code: 6
whale	king	caesar	love
boat	came	brutus	soul
sperm	michael	bru	thee
ship	jackal	cassi	shall
ahab	fir	haue	song
stubb	story	cassius	earth
sea	tree	cask	land
though	brown	caes	thy
water	mr	antony	woman
leviathan	cross	brut	city

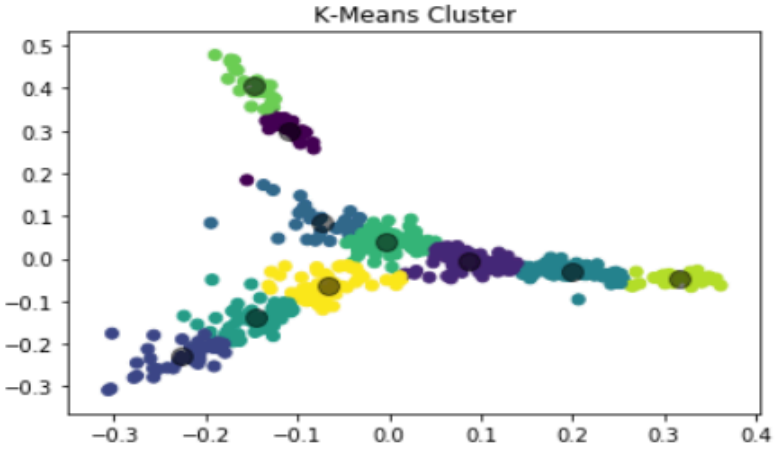
Top terms from KNN clusters:	Associated with author codes:
0,2,5,7 and 9	6 - Leaves
3 and 4	8 – Moby Dick
1	7 - Macbeth

Cluster analysis – Visual Distribution of top terms for each KNN cluster



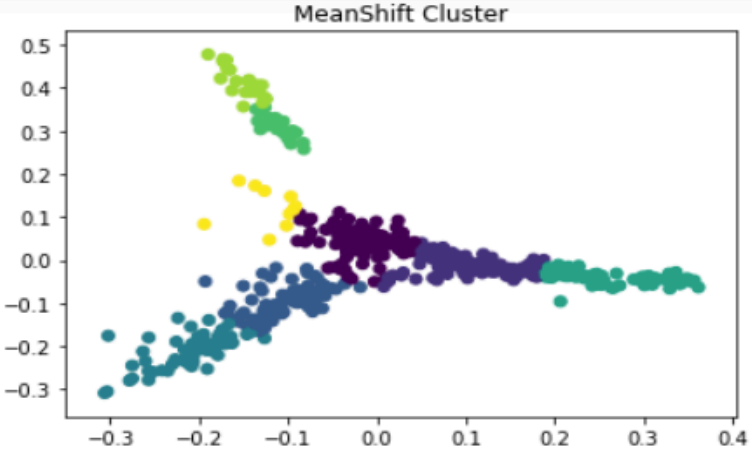
Cluster visualizations: Kmeans and MeanShift

Graphically visualization of each cluster



Comparing k-means clusters against author codes:

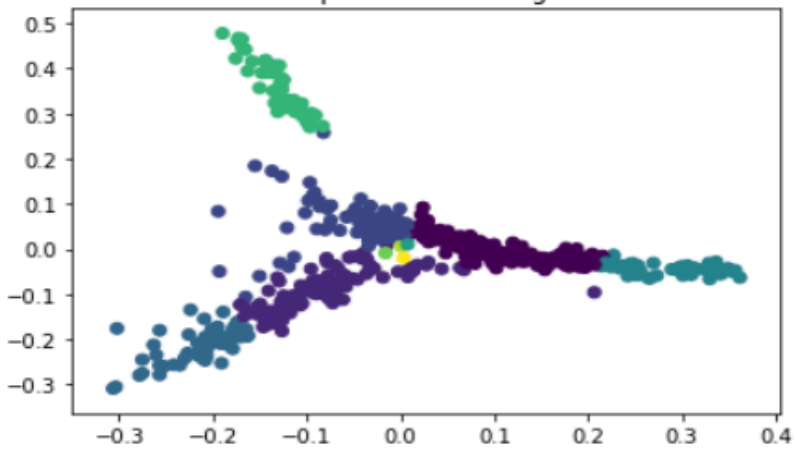
col_0	0	1	2	3	4	5	6	7	8	9	Total
author_codes											
0	0	9	0	0	28	0	2	0	28	0	67
1	0	48	0	0	6	0	0	0	0	0	54
2	0	7	0	0	0	0	23	0	0	1	31
3	0	13	0	0	0	0	0	0	0	0	13
4	12	0	0	0	0	0	0	2	0	0	14
5	3	0	0	0	0	0	0	18	0	0	21
6	1	0	0	29	0	0	71	0	0	0	101
7	9	0	0	0	0	0	0	4	0	0	13
8	0	4	39	4	0	54	2	0	0	55	158
9	0	6	0	0	32	0	1	0	0	0	39
Total	25	87	39	33	66	54	99	24	28	56	511



Comparing meanshift clusters against authors:

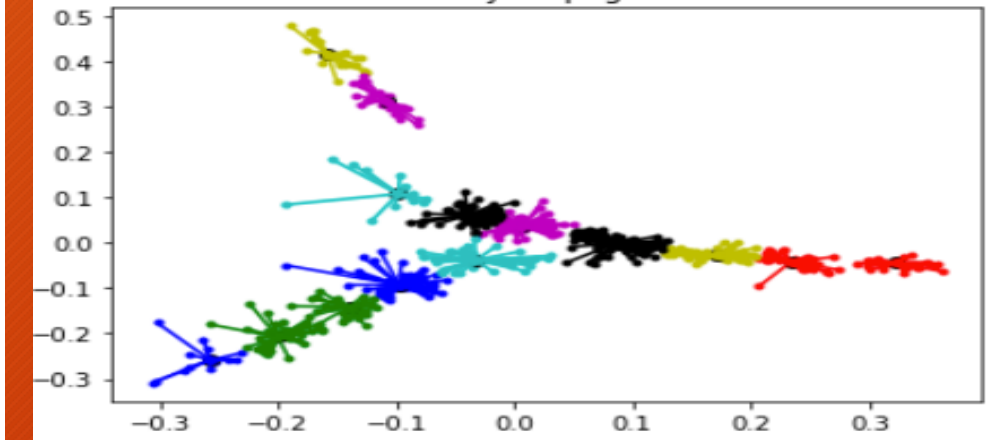
col_0	0	1	2	3	4	5	6	7	Total
author_codes									
0	2	13	0	0	52	0	0	0	67
1	0	54	0	0	0	0	0	0	54
2	22	8	1	0	0	0	0	0	31
3	0	13	0	0	0	0	0	0	13
4	0	0	0	0	0	13	1	0	14
5	0	0	0	0	0	3	18	0	21
6	92	0	0	0	0	0	0	9	101
7	0	0	0	0	0	11	2	0	13
8	15	7	79	56	0	0	0	1	158
9	1	21	0	0	17	0	0	0	39
Total	132	116	80	56	69	27	21	10	511

Cluster visualizations Spectral and Affinity



Comparing spectral clusters against authors:

col_0	0	1	2	3	4	5	6	7	8	9	Total
author_codes											
0	49	15	0	0	0	2	0	0	0	1	67
1	0	52	0	0	0	2	0	0	0	0	54
2	0	28	0	0	0	1	0	0	0	2	31
3	0	13	0	0	0	0	0	0	0	0	13
4	0	0	0	0	14	0	0	0	0	0	14
5	0	0	0	0	21	0	0	0	0	0	21
6	0	8	0	1	0	1	1	0	1	89	101
7	0	0	0	0	13	0	0	0	0	0	13
8	0	0	50	0	0	92	0	1	0	15	158
9	5	34	0	0	0	0	0	0	0	0	39
Total	54	150	50	1	48	98	1	1	1	107	511



Comparing affinity clusters against authors:

col_0	0	1	2	3	4	5	6	7	8	9	10	11	12	13	Total
author_codes															
0	0	0	24	0	2	0	0	0	0	26	0	0	7	8	67
1	0	0	0	0	0	0	0	0	0	0	0	0	9	45	54
2	0	0	0	0	21	0	2	1	0	0	0	0	0	7	31
3	0	0	0	0	0	0	0	0	0	0	0	0	0	13	13
4	0	0	0	0	0	0	0	0	0	0	0	14	0	0	14
5	0	0	0	0	0	18	0	0	0	0	0	3	0	0	21
6	0	0	0	13	41	0	45	0	0	0	2	0	0	0	101
7	0	0	0	0	0	2	0	0	0	0	0	11	0	0	13
8	14	31	0	1	0	0	3	44	35	0	29	0	0	1	158
9	0	0	0	0	1	0	0	0	0	5	0	0	30	3	39
Total	14	31	24	14	65	20	50	45	35	31	31	28	46	77	511

Estimated number of clusters: 14

Cluster evaluation results

Overall Spectral Clustering performed the best based on the Random Index (RI) Adjusted score.

	Cluster	Number of clusters	RI Score	RI adjusted score
0	K-Means	10	0.0171759	0.473769
1	MeanShift	8	0.0289061	0.465032
2	SpectralClustering	10	0.00935582	0.495523
3	AffinityPropagation	14	0.0138365	0.343228

Model Performance – Random Forest

```
RFC Training mean set score: 0.8046533422135997
RFC Testing mean set score: 0.654399419643352 5

 Random Forest confusion matrix
 [[10  3  0  0  0  0  1  0  1  0]
 [ 4 12  0  0  0  0  0  0  1  1]
 [ 1  1 11  0  0  0  2  0  1  0]
 [ 1  0  1  1  0  0  0  0  0  0]
 [ 0  0  0  0  4  2  1  0  0  0]
 [ 0  0  0  0  0  9  0  0  0  0]
 [ 0  0  0  0  0  0 22  0  0  0]
 [ 0  0  0  0  0  1  0  4  0  0]
 [ 0  0  0  0  0  0  1  0 55  0]
 [ 1  2  0  0  0  0  3  0  4 10]]

 Random Forest classification report
                precision    recall  f1-score   support

             0       0.59      0.67      0.62        15
             1       0.67      0.67      0.67        18
             2       0.92      0.69      0.79        16
             3       1.00      0.33      0.50         3
             4       1.00      0.57      0.73         7
             5       0.75      1.00      0.86         9
             6       0.73      1.00      0.85        22
             7       1.00      0.80      0.89         5
             8       0.89      0.98      0.93        56
             9       0.91      0.50      0.65        20

   micro avg       0.81      0.81      0.81       171
   macro avg       0.85      0.72      0.75       171
weighted avg       0.83      0.81      0.80       171

Random Forest accuracy score: 0.8070175438596491
```

Model Performance – Logistic regression

```
LR Training mean set score: 0.9240892056625226
LR Testing mean set score: 0.5687751756050468

 Logistic regression confusion matrix
 [[15  0  0  0  0  0  0  0  0  0]
 [ 0 18  0  0  0  0  0  0  0  0]
 [ 0  0  5  0  0  0  4  0  7  0]
 [ 0  0  0  3  0  0  0  0  0  0]
 [ 0  0  0  0  7  0  0  0  0  0]
 [ 0  0  0  0  0  9  0  0  0  0]
 [ 0  0  0  0  0  0 22  0  0  0]
 [ 0  0  0  0  0  0  0  5  0  0]
 [ 0  0  0  0  0  0  0  0 56  0]
 [ 0  0  0  0  0  0  1  0  0 19]]

 Logistic classification report
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        15
           1       1.00      1.00      1.00        18
           2       1.00      0.31      0.48        16
           3       1.00      1.00      1.00         3
           4       1.00      1.00      1.00         7
           5       1.00      1.00      1.00         9
           6       0.81      1.00      0.90        22
           7       1.00      1.00      1.00         5
           8       0.89      1.00      0.94        56
           9       1.00      0.95      0.97        20

   micro avg       0.93      0.93      0.93       171
   macro avg       0.97      0.93      0.93       171
weighted avg       0.94      0.93      0.92       171

Logistic accuracy score:  0.9298245614035088
```

Model Performance – Gradient Boosting

```
Gradient Training mean set score: 0.941343564920112
Gradient Testing mean set score: 0.859236603526526

 Gradient Boosting confusion matrix
 [[15  0  0  0  0  0  0  0  0  0]
 [ 0 18  0  0  0  0  0  0  0  0]
 [ 0  0 13  0  0  0  1  0  2  0]
 [ 0  0  0  3  0  0  0  0  0  0]
 [ 0  0  0  0  7  0  0  0  0  0]
 [ 0  0  0  0  0  8  0  0  1  0]
 [ 0  1  0  0  0  0 21  0  0  0]
 [ 0  0  0  0  0  0  0  5  0  0]
 [ 0  0  0  0  0  1  0  0 55  0]
 [ 0  0  0  0  0  0  0  0  0 20]]

 Gradient Boosting classification report
              precision    recall  f1-score   support

           0       1.00      1.00      1.00        15
           1       0.95      1.00      0.97        18
           2       1.00      0.81      0.90        16
           3       1.00      1.00      1.00         3
           4       1.00      1.00      1.00         7
           5       0.89      0.89      0.89         9
           6       0.95      0.95      0.95        22
           7       1.00      1.00      1.00         5
           8       0.95      0.98      0.96        56
           9       1.00      1.00      1.00        20

   micro avg       0.96      0.96      0.96       171
   macro avg       0.97      0.96      0.97       171
weighted avg       0.97      0.96      0.96       171

Gradient Boosting accuracy score: 0.9649122807017544
```

Model Performance - Knn

```
KNN Training mean set score: 0.9786117517268057
KNN Testing mean set score: 0.9363743799727022

 KNN Confustion Matrix
 [[15  0  0  0  0  0  0  0  0  0]
 [ 0 18  0  0  0  0  0  0  0  0]
 [ 0  1 14  0  0  0  1  0  0  0]
 [ 0  0  0  3  0  0  0  0  0  0]
 [ 0  0  0  0  7  0  0  0  0  0]
 [ 0  0  0  0  0  9  0  0  0  0]
 [ 0  0  0  0  0  0 22  0  0  0]
 [ 0  0  0  0  0  0  0  5  0  0]
 [ 0  0  0  0  0  0  0  0 56  0]
 [ 0  0  0  0  0  0  0  0  0 20]]

 KNN Classification Report
               precision    recall  f1-score   support

            0       1.00      1.00      1.00        15
            1       0.95      1.00      0.97        18
            2       1.00      0.88      0.93        16
            3       1.00      1.00      1.00         3
            4       1.00      1.00      1.00         7
            5       1.00      1.00      1.00         9
            6       0.96      1.00      0.98        22
            7       1.00      1.00      1.00         5
            8       1.00      1.00      1.00        56
            9       1.00      1.00      1.00        20

    micro avg       0.99      0.99      0.99       171
    macro avg       0.99      0.99      0.99       171
weighted avg       0.99      0.99      0.99       171


 KNN accuracy score: 0.9883040935672515
```

Model Performance – Support Vector

```
SVC Training mean set score: 0.9942846872753414
SVC Testing mean set score: 0.9827296736464819

 Support vector cufusion matrix
 [[15  0  0  0  0  0  0  0  0  0]
 [ 0 18  0  0  0  0  0  0  0  0]
 [ 0  0 15  0  0  0  0  0  1  0]
 [ 0  0  0  3  0  0  0  0  0  0]
 [ 0  0  0  0  7  0  0  0  0  0]
 [ 0  0  0  0  0  9  0  0  0  0]
 [ 0  0  0  0  0  0 22  0  0  0]
 [ 0  0  0  0  0  0  0  5  0  0]
 [ 0  0  0  0  0  0  0  0 56  0]
 [ 0  0  0  0  0  0  0  0  0 20]]

 Support vector classification report
                    precision    recall  f1-score   support

                 0       1.00      1.00      1.00        15
                 1       1.00      1.00      1.00        18
                 2       1.00      0.94      0.97        16
                 3       1.00      1.00      1.00         3
                 4       1.00      1.00      1.00         7
                 5       1.00      1.00      1.00         9
                 6       1.00      1.00      1.00        22
                 7       1.00      1.00      1.00         5
                 8       0.98      1.00      0.99        56
                 9       1.00      1.00      1.00        20

    micro avg       0.99      0.99      0.99       171
    macro avg       1.00      0.99      1.00       171
weighted avg       0.99      0.99      0.99       171


 Support vector accuracy score: 0.9941520467836257
```

Summary results: Cluster and model performance

- Based on the crosstab results of the clusters, authors were not consistently grouped into the same cluster.
- I was expecting more clustering to occur on members who had more words per documents but the results of the clusters were not consistent with my expectation.
- Overall the clusters remained stable for every type of cluster (i.e. Kmeans, meanshift, spectural…etc.)
- Overall Model performance:
  - KNN and SVM where consistent with each other with as their accuracy scores range from 98 and 99%
  - Logistic regression, Random forest and Gradient boosting were not consistent as their accuracy scores range from 80, 92 and 96%