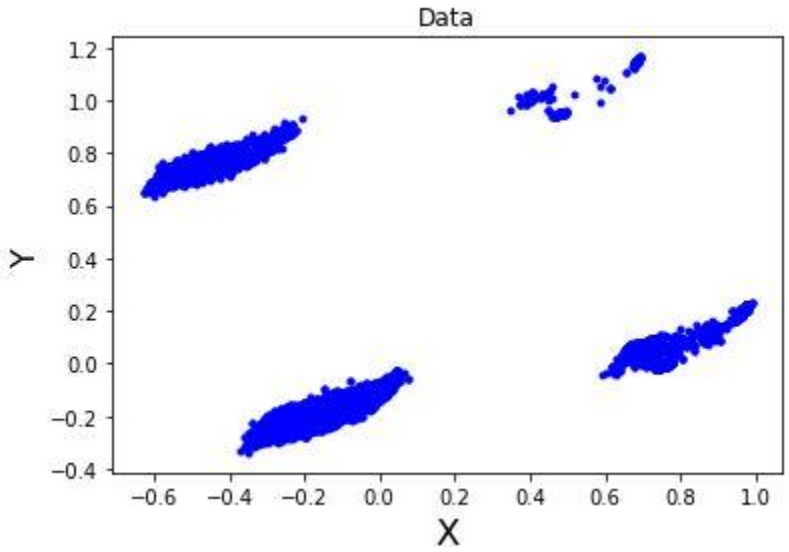
HR Project

Clustering and Outliers Analysis:

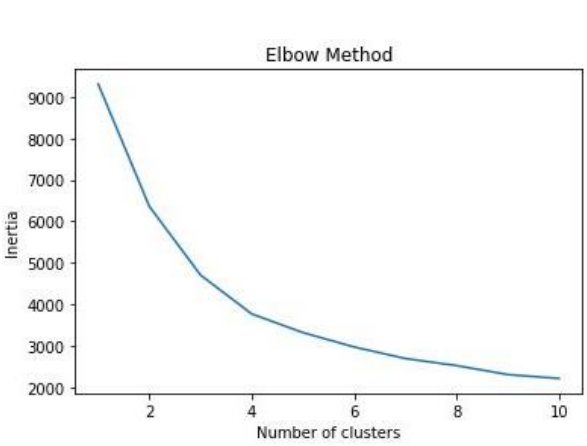
Clustering Analysis:

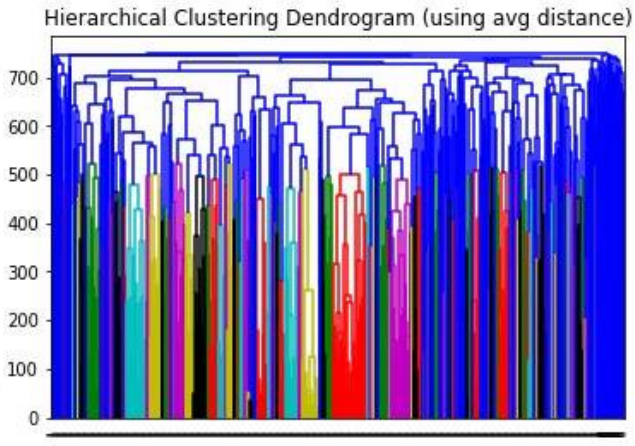
In clustering analysis, the most important thing to decide is, how many optimal number of clusters are in data. It can either be decided by visualizing data or elbow method.

For **visualizing data**, it was converted into **2-dimensional data using PCA technique**, and from the figure below, it can be clearly seen that number of optimal clusters for data is 4.



Other techniques like elbow technique and visualization of hierarchical tree of the data, also showed the same results. The figures of both techniques mentioned earlier are given below.

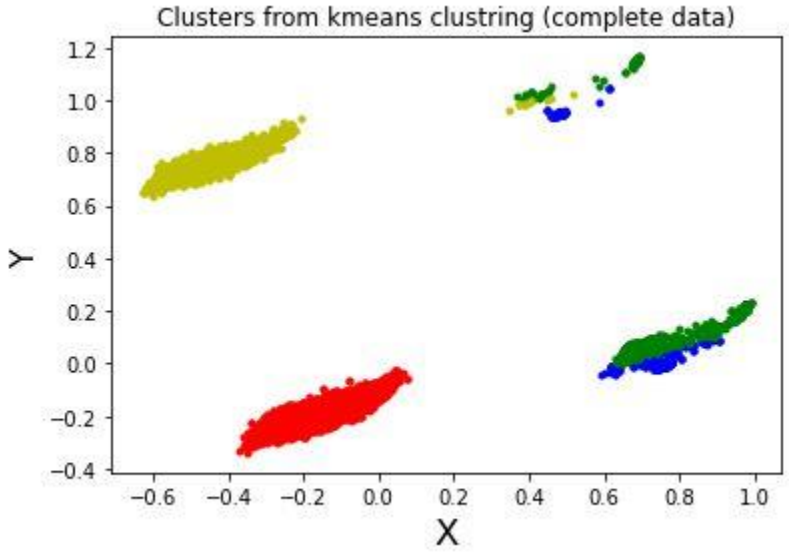




Graphs, data statistics and results of the clusters, made using different clustering techniques are shown below:

K-means Clustering:

As, number of optimal number of clusters are known, we ran K-means clustering on data and got following results:



It is visible that clusters are well formed but there are some outliers in them.

Now let us analyze the data by grouping it on base of K-means labels.

	satisfaction_level	last_evaluation	number_project	average_montly_hours	time_spend_company	Work_accident	promotion_last_5years	salary	left
count	1632.000000	1632.000000	1632.000000	1632.000000	1632.000000	1632.000000	1632.000000	1632.000000	1632.0
mean	0.415025	0.520705	2.077819	147.297181	3.051471	0.046569	0.009191	0.419118	1.0
std	0.070913	0.063042	0.392384	20.823436	0.342813	0.210778	0.095458	0.555516	0.0
min	0.100000	0.450000	2.000000	126.000000	2.000000	0.000000	0.000000	0.000000	1.0
25%	0.380000	0.480000	2.000000	135.000000	3.000000	0.000000	0.000000	0.000000	1.0
50%	0.410000	0.510000	2.000000	145.000000	3.000000	0.000000	0.000000	0.000000	1.0
75%	0.440000	0.550000	2.000000	154.000000	3.000000	0.000000	0.000000	1.000000	1.0
max	0.890000	1.000000	6.000000	301.000000	6.000000	1.000000	1.000000	2.000000	1.0

	satisfaction_level	last_evaluation	number_project	average_montly_hours	time_spend_company	Work_accident	promotion_last_5years	salary	left
count	1927.000000	1927.000000	1927.000000	1927.000000	1927.000000	1927.000000	1927.000000	1927.000000	1927.0
mean	0.459175	0.884759	5.359107	258.280228	4.570835	0.042034	0.002076	0.411002	1.0
std	0.350847	0.090415	1.027528	30.319334	0.776097	0.200719	0.045525	0.521842	0.0
min	0.090000	0.450000	2.000000	132.000000	2.000000	0.000000	0.000000	0.000000	1.0
25%	0.100000	0.840000	5.000000	243.000000	4.000000	0.000000	0.000000	0.000000	1.0
50%	0.460000	0.890000	5.000000	259.000000	5.000000	0.000000	0.000000	0.000000	1.0
75%	0.810000	0.950000	6.000000	278.000000	5.000000	0.000000	0.000000	1.000000	1.0
max	0.920000	1.000000	7.000000	310.000000	6.000000	1.000000	1.000000	2.000000	1.0

	satisfaction_level	last_evaluation	number_project	average_montly_hours	time_spend_company	Work_accident	promotion_last_5years	salary	left
count	2012.000000	2012.000000	2012.000000	2012.000000	2012.000000	2012.0	2012.000000	2012.000000	2012.000000
mean	0.666059	0.713415	3.791252	199.488569	3.479125	1.0	0.035785	0.622266	0.005964
std	0.218819	0.163720	0.997841	45.903097	1.695362	0.0	0.185801	0.652777	0.077017
min	0.120000	0.360000	2.000000	96.000000	2.000000	1.0	0.000000	0.000000	0.000000
25%	0.540000	0.580000	3.000000	161.000000	2.000000	1.0	0.000000	0.000000	0.000000
50%	0.680000	0.720000	4.000000	199.000000	3.000000	1.0	0.000000	1.000000	0.000000
75%	0.830000	0.850000	4.000000	238.000000	4.000000	1.0	0.000000	1.000000	0.000000
max	1.000000	1.000000	6.000000	287.000000	10.000000	1.0	1.000000	2.000000	1.000000

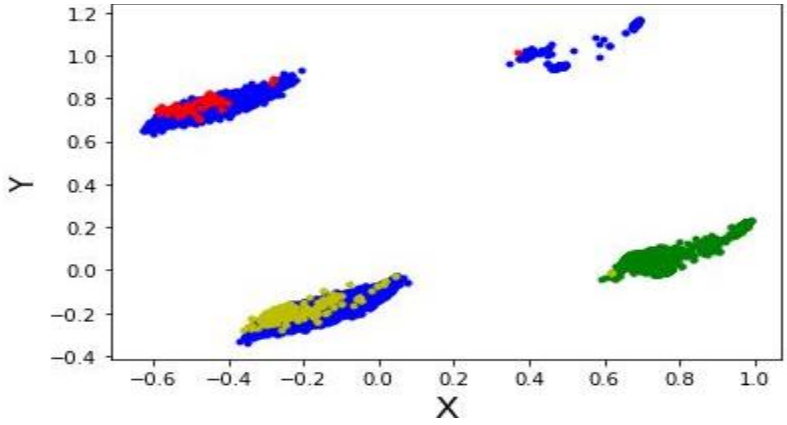
	satisfaction_level	last_evaluation	number_project	average_montly_hours	time_spend_company	Work_accident	promotion_last_5years	salary	left
count	9428.000000	9428.000000	9428.000000	9428.000000	9428.000000	9428.0	9428.000000	9428.000000	9428.0
mean	0.667122	0.716027	3.786169	198.991090	3.360416	0.0	0.024183	0.656767	0.0
std	0.216710	0.161592	0.975619	45.624039	1.531858	0.0	0.153626	0.655557	0.0
min	0.120000	0.360000	2.000000	96.000000	2.000000	0.0	0.000000	0.000000	0.0
25%	0.540000	0.580000	3.000000	162.000000	2.000000	0.0	0.000000	0.000000	0.0
50%	0.690000	0.720000	4.000000	198.000000	3.000000	0.0	0.000000	1.000000	0.0
75%	0.840000	0.850000	4.000000	238.000000	4.000000	0.0	0.000000	1.000000	0.0
max	1.000000	1.000000	6.000000	287.000000	10.000000	0.0	1.000000	2.000000	0.0

From the above statistics, we can define K-means clusters of data as:

- Employee with **low** satisfaction level, evaluation score, number of projects, average monthly hours and salary, who **left**,
- Employee with **low** satisfaction level and salary but **high** number of projects, average monthly hours, who **left,**
- Employee with **high** satisfaction level, evaluation score and salary but with **lower** number of projects and average monthly hours, but **no work accident** and **stayed**,
- Employee with **high** satisfaction level, evaluation score and salary but with **lower** number of projects and average monthly hours, but **had work accident** and **stayed**.

Similar results were achieved from Birch clustering technique, but **Birch** gave high importance to **promotion** and **work accident**.

Figure of clustering is given below:



It can be seen that, clusters are well formed but there are some outliers in them.

Now let us analyze the data by grouping it on base of Birch labels.

	satisfaction_level	last_evaluation	number_project	average_montly_hours	time_spend_company	Work_accident	promotion_last_5years	salary	left
count	3399.000000	3399.000000	3399.000000	3399.000000	3399.00000	3399.0	3399.000000	3399.000000	3399.0
mean	0.439444	0.718308	3.858782	207.603119	3.87614	0.0	0.003530	0.413945	1.0
std	0.263392	0.197760	1.824415	61.317451	0.97871	0.0	0.059321	0.539379	0.0
min	0.090000	0.450000	2.000000	126.000000	2.00000	0.0	0.000000	0.000000	1.0
25%	0.120000	0.520000	2.000000	146.000000	3.00000	0.0	0.000000	0.000000	1.0
50%	0.410000	0.790000	4.000000	225.000000	4.00000	0.0	0.000000	0.000000	1.0
75%	0.725000	0.900000	6.000000	262.000000	5.00000	0.0	0.000000	1.000000	1.0
max	0.920000	1.000000	7.000000	310.000000	6.00000	0.0	1.000000	2.000000	1.0

	satisfaction_level	last_evaluation	number_project	average_montly_hours	time_spend_company	Work_accident	promotion_last_5years	salary	left
count	73.000000	73.000000	73.000000	73.000000	73.000000	73.0	73.0	73.000000	73.000000
mean	0.665890	0.724521	3.684932	216.095890	4.178082	1.0	1.0	1.000000	0.013699
std	0.194785	0.206337	1.165198	47.622988	1.924567	0.0	0.0	0.645497	0.117041
min	0.160000	0.380000	2.000000	100.000000	2.000000	1.0	1.0	0.000000	0.000000
25%	0.570000	0.550000	3.000000	183.000000	3.000000	1.0	1.0	1.000000	0.000000
50%	0.650000	0.800000	4.000000	222.000000	3.000000	1.0	1.0	1.000000	0.000000
75%	0.790000	0.880000	4.000000	259.000000	6.000000	1.0	1.0	1.000000	0.000000
max	1.000000	1.000000	6.000000	275.000000	10.000000	1.0	1.0	2.000000	1.000000

	satisfaction_level	last_evaluation	number_project	average_montly_hours	time_spend_company	Work_accident	promotion_last_5years	salary	lef
count	11296.000000	11296.000000	11296.000000	11296.000000	11296.000000	11296.000000	11296.000000	11296.000000	11296.00000
mean	0.663461	0.715516	3.786385	199.084720	3.365262	0.185552	0.000266	0.636686	0.01487
std	0.219957	0.162406	0.994075	45.864575	1.529145	0.388762	0.016295	0.650464	0.12104
min	0.090000	0.360000	2.000000	96.000000	2.000000	0.000000	0.000000	0.000000	0.00000
25%	0.530000	0.580000	3.000000	161.000000	2.000000	0.000000	0.000000	0.000000	0.00000
50%	0.690000	0.720000	4.000000	198.000000	3.000000	0.000000	0.000000	1.000000	0.00000
75%	0.840000	0.850000	4.000000	238.000000	4.000000	0.000000	0.000000	1.000000	0.00000
max	1.000000	1.000000	7.000000	309.000000	10.000000	1.000000	1.000000	2.000000	1.00000

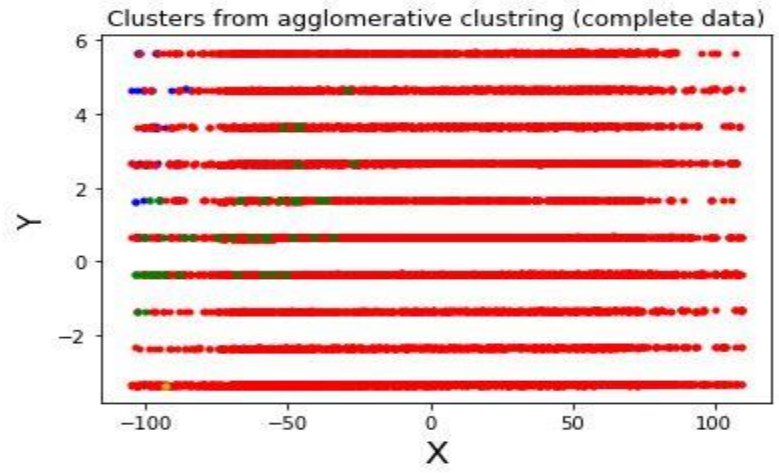
	satisfaction_level	last_evaluation	number_project	average_montly_hours	time_spend_company	Work_accident	promotion_last_5years	salary	left
count	231.000000	231.000000	231.000000	231.000000	231.000000	231.0	231.0	231.000000	231.000000
mean	0.671688	0.709610	3.835498	195.995671	4.225108	0.0	1.0	1.073593	0.012987
std	0.209079	0.154915	0.936573	46.568930	2.286344	0.0	0.0	0.645213	0.113464
min	0.150000	0.370000	2.000000	102.000000	2.000000	0.0	1.0	0.000000	0.000000
25%	0.530000	0.590000	3.000000	152.000000	3.000000	0.0	1.0	1.000000	0.000000
50%	0.720000	0.710000	4.000000	196.000000	3.000000	0.0	1.0	1.000000	0.000000
75%	0.820000	0.820000	4.000000	233.000000	6.000000	0.0	1.0	1.000000	0.000000
max	1.000000	1.000000	6.000000	286.000000	10.000000	0.0	1.0	2.000000	1.000000

From the above statistics, we can define clusters from Birch of data as:

- Employee with **low** satisfaction level, evaluation score and salary. And had **no work accident** and **left**,
- Employee with **high** satisfaction level, evaluation score and salary but with **lower** average monthly hours. But had **no work accident** and **no promotion** and **stayed**,
- Employee with **high** satisfaction level, evaluation score and salary but with **lower** number of projects, average monthly hours. And **got promotion** but **had work accident** and **stayed**.
- Employee with **high** satisfaction level, evaluation score and **very high salary** and **got promotion** and **stayed**.

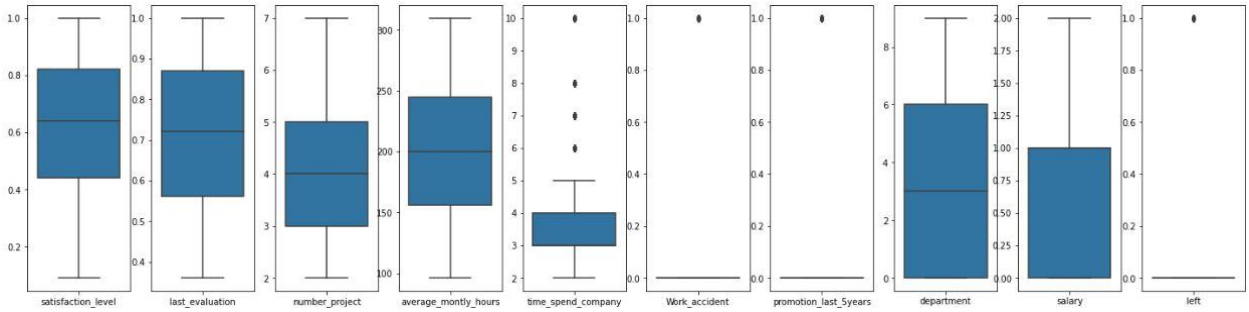
Agglomerative clustering was also tried, but no meaningful clusters were extracted from Agglomerative clustering.

Figure of clusters is given below:



Outliers Analysis:

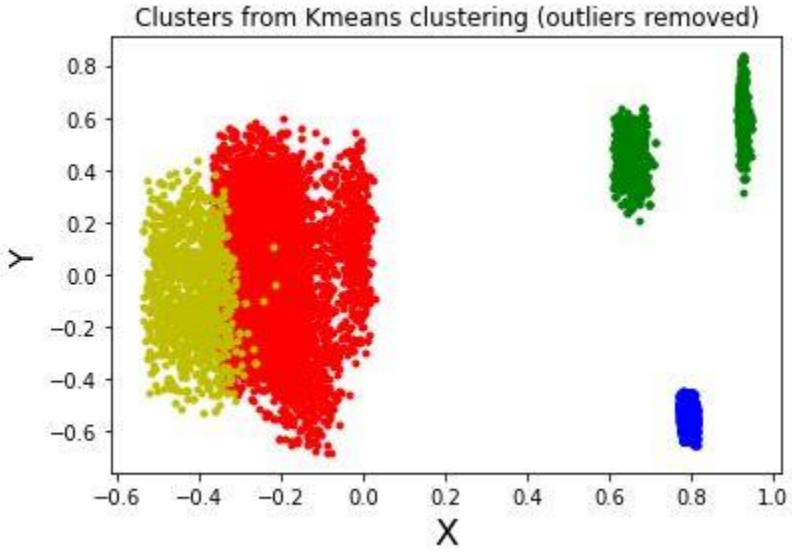
Outliers in the data depends upon the objective we are trying to achieve, like from the below figure we can see that in attribute “left” of the data, value ‘1’ is outlier. But since our objective is to figure the reasons behind, why employee left and how can they be retained in future. So, it makes it clear that we can not declare outliers by looking on a single attribute, so we cannot use boxplot, z score or IQR for outliers analysis, since they will declare employee who left, had promotion or work accident as outliers.



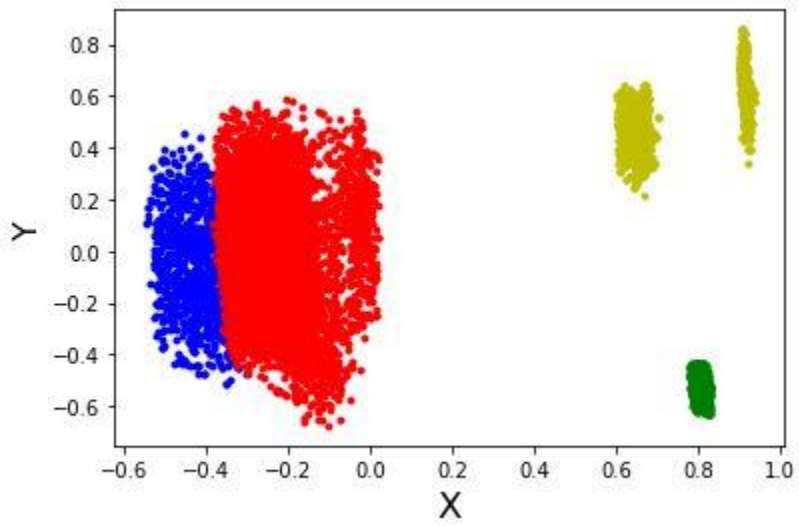
Therefore, outlier detection technique which will be useful for our objective is “Isolation Forest”.

The clusters extracted after applying “Isolation Forest” are shown in the figures below:

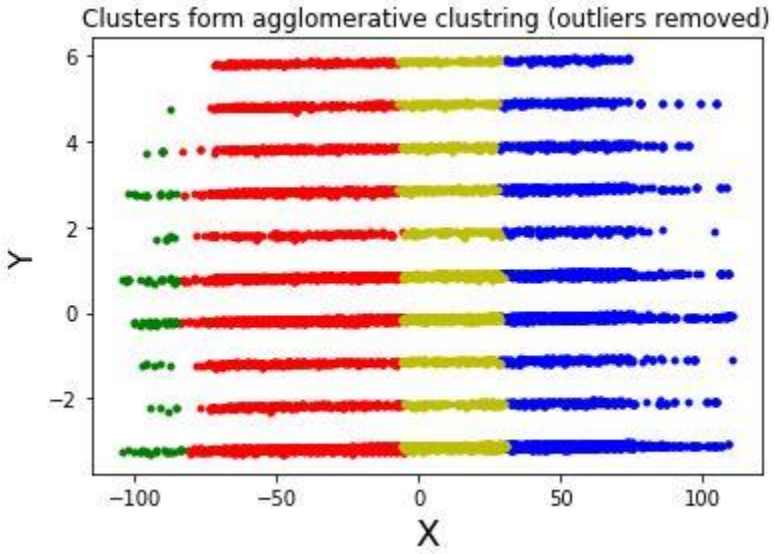
K-means:



BIRCH:



Agglomerative Clustering:



After removal of outliers, it is visible that K-means and Birch gave very clear clusters with almost no outliers or overlapping. But agglomerative clustering were not clearly separated.

Now, let us check statistics of clusters after outlier removal.

K-means:

After removal outliers, it can be seen the employees despite having all the problems like **low** salary, satisfaction level and high average monthly hours **did not leave** are considered as **outlier** or we can also say **exception** and **removed**.
As a result, we got perfect clusters with zero standard deviation in “left” column, which are shown below:

	satisfaction_level	last_evaluation	number_project	average_montly_hours	time_spend_company	Work_accident	promotion_last_5years	left
count	731.000000	731.000000	731.000000	731.000000	731.000000	731.0	731.0	731.0
mean	0.797177	0.879980	0.526402	0.703766	0.391245	0.0	0.0	1.0
std	0.062423	0.089779	0.096518	0.073695	0.042061	0.0	0.0	0.0
min	0.626374	0.656250	0.400000	0.565421	0.375000	0.0	0.0	1.0
25%	0.747253	0.796875	0.400000	0.644860	0.375000	0.0	0.0	1.0
50%	0.802198	0.875000	0.600000	0.700935	0.375000	0.0	0.0	1.0
75%	0.846154	0.968750	0.600000	0.761682	0.375000	0.0	0.0	1.0
max	0.912088	1.000000	0.600000	0.841121	0.500000	0.0	0.0	1.0

	satisfaction_level	last_evaluation	number_project	average_montly_hours	time_spend_company	Work_accident	promotion_last_5years	left
count	1432.000000	1432.000000	1432.0	1432.000000	1432.000	1432.0	1432.0	1432.0
mean	0.349408	0.235815	0.0	0.222390	0.125	0.0	0.0	1.0
std	0.033114	0.056305	0.0	0.047300	0.000	0.0	0.0	0.0
min	0.296703	0.140625	0.0	0.140187	0.125	0.0	0.0	1.0
25%	0.318681	0.187500	0.0	0.182243	0.125	0.0	0.0	1.0
50%	0.351648	0.234375	0.0	0.224299	0.125	0.0	0.0	1.0
75%	0.373626	0.281250	0.0	0.261682	0.125	0.0	0.0	1.0
max	0.406593	0.328125	0.0	0.303738	0.125	0.0	0.0	1.0

	satisfaction_level	last_evaluation	number_project	average_montly_hours	time_spend_company	Work_accident	promotion_last_5years	left
count	1566.000000	1566.000000	1566.000000	1566.000000	1566.000000	1566.0	1566.0	1566.0
mean	0.717493	0.813388	0.339336	0.333915	0.122925	0.0	0.0	0.0
std	0.158684	0.111796	0.158501	0.102939	0.123577	0.0	0.0	0.0
min	0.340659	0.578125	0.000000	0.009346	0.000000	0.0	0.0	0.0
25%	0.593407	0.718750	0.200000	0.252336	0.000000	0.0	0.0	0.0
50%	0.714286	0.812500	0.400000	0.336449	0.125000	0.0	0.0	0.0
75%	0.846154	0.906250	0.400000	0.420561	0.125000	0.0	0.0	0.0
max	1.000000	1.000000	0.800000	0.528037	0.750000	0.0	0.0	0.0

	satisfaction_level	last_evaluation	number_project	average_montly_hours	time_spend_company	Work_accident	promotion_last_5years	left
count	1077.000000	1077.000000	1077.000000	1077.000000	1077.000000	1077.0	1077.0	1077.0
mean	0.685645	0.549661	0.340019	0.488342	0.102484	1.0	0.0	0.0
std	0.160499	0.218006	0.140118	0.180474	0.081111	0.0	0.0	0.0
min	0.153846	0.140625	0.200000	0.098131	0.000000	1.0	0.0	0.0
25%	0.560440	0.359375	0.200000	0.331776	0.000000	1.0	0.0	0.0
50%	0.681319	0.546875	0.400000	0.481308	0.125000	1.0	0.0	0.0
75%	0.813187	0.718750	0.400000	0.640187	0.125000	1.0	0.0	0.0
max	1.000000	1.000000	0.600000	0.831776	0.375000	1.0	0.0	0.0

Birch:

Similar effect of **outlier removal** was observed in Birch's cluster output, Employees who despite having similar properties decided opposite on whether to leave or not, as compare to majority, were considered **outlier or exception** and was **removed**.

Statistics of clusters are shown in figures below:

	satisfaction_level	last_evaluation	number_project	average_montly_hours	time_spend_company	Work_accident	promotion_last_5years	salary	left
count	3399.000000	3399.000000	3399.000000	3399.000000	3399.00000	3399.0	3399.000000	3399.000000	3399.0
mean	0.439444	0.718308	3.858782	207.603119	3.87614	0.0	0.003530	0.413945	1.0
std	0.263392	0.197760	1.824415	61.317451	0.97871	0.0	0.059321	0.539379	0.0
min	0.090000	0.450000	2.000000	126.000000	2.00000	0.0	0.000000	0.000000	1.0
25%	0.120000	0.520000	2.000000	146.000000	3.00000	0.0	0.000000	0.000000	1.0
50%	0.410000	0.790000	4.000000	225.000000	4.00000	0.0	0.000000	0.000000	1.0
75%	0.725000	0.900000	6.000000	262.000000	5.00000	0.0	0.000000	1.000000	1.0
max	0.920000	1.000000	7.000000	310.000000	6.00000	0.0	1.000000	2.000000	1.0

	satisfaction_level	last_evaluation	number_project	average_montly_hours	time_spend_company	Work_accident	promotion_last_5years	salary	left
count	73.000000	73.000000	73.000000	73.000000	73.000000	73.0	73.0	73.000000	73.000000
mean	0.665890	0.724521	3.684932	216.095890	4.178082	1.0	1.0	1.000000	0.013699
std	0.194785	0.206337	1.165198	47.622988	1.924567	0.0	0.0	0.645497	0.117041
min	0.160000	0.380000	2.000000	100.000000	2.000000	1.0	1.0	0.000000	0.000000
25%	0.570000	0.550000	3.000000	183.000000	3.000000	1.0	1.0	1.000000	0.000000
50%	0.650000	0.800000	4.000000	222.000000	3.000000	1.0	1.0	1.000000	0.000000
75%	0.790000	0.880000	4.000000	259.000000	6.000000	1.0	1.0	1.000000	0.000000
max	1.000000	1.000000	6.000000	275.000000	10.000000	1.0	1.0	2.000000	1.000000

satisfaction_level	last_evaluation	number_project	average_montly_hours	time_spend_company	Work_accident	promotion_last_5years	salary	left
11296.000000	11296.000000	11296.000000	11296.000000	11296.000000	11296.000000	11296.000000	11296.000000	11296.000000
0.663461	0.715516	3.786385	199.084720	3.365262	0.185552	0.000266	0.636686	0.014873
0.219957	0.162406	0.994075	45.864575	1.529145	0.388762	0.016295	0.650464	0.121048
0.090000	0.360000	2.000000	96.000000	2.000000	0.000000	0.000000	0.000000	0.000000
0.530000	0.580000	3.000000	161.000000	2.000000	0.000000	0.000000	0.000000	0.000000
0.690000	0.720000	4.000000	198.000000	3.000000	0.000000	0.000000	1.000000	0.000000
0.840000	0.850000	4.000000	238.000000	4.000000	0.000000	0.000000	1.000000	0.000000
1.000000	1.000000	7.000000	309.000000	10.000000	1.000000	1.000000	2.000000	1.000000

	satisfaction_level	last_evaluation	number_project	average_montly_hours	time_spend_company	Work_accident	promotion_last_5years	salary	left
count	231.000000	231.000000	231.000000	231.000000	231.000000	231.0	231.0	231.000000	231.000000
mean	0.671688	0.709610	3.835498	195.995671	4.225108	0.0	1.0	1.073593	0.012987
std	0.209079	0.154915	0.936573	46.568930	2.286344	0.0	0.0	0.645213	0.113464
min	0.150000	0.370000	2.000000	102.000000	2.000000	0.0	1.0	0.000000	0.000000
25%	0.530000	0.590000	3.000000	152.000000	3.000000	0.0	1.0	1.000000	0.000000
50%	0.720000	0.710000	4.000000	196.000000	3.000000	0.0	1.0	1.000000	0.000000
75%	0.820000	0.820000	4.000000	233.000000	6.000000	0.0	1.0	1.000000	0.000000
max	1.000000	1.000000	6.000000	286.000000	10.000000	0.0	1.0	2.000000	1.000000

Agglomerative Clustering:

Even after the removal of outliers, no meaningful clusters (for the objective) were obtained using agglomerative clusters.