CMPT 459 Assignment 5

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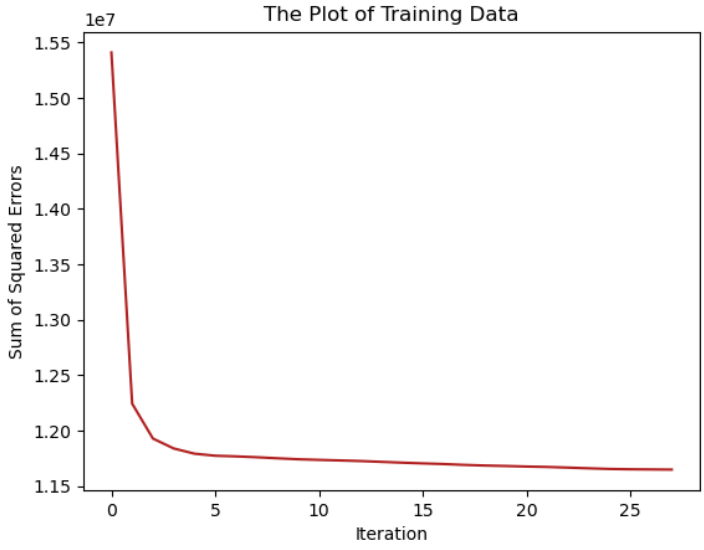
Question 1

I set the parameter $verbose = True$ of $KMean()$ function to display the SSE for each iteration. And I modified the Scikit-learn k-means source code by adding a list SSE variable to get those SSE.
Here, the inertia is the SSE.

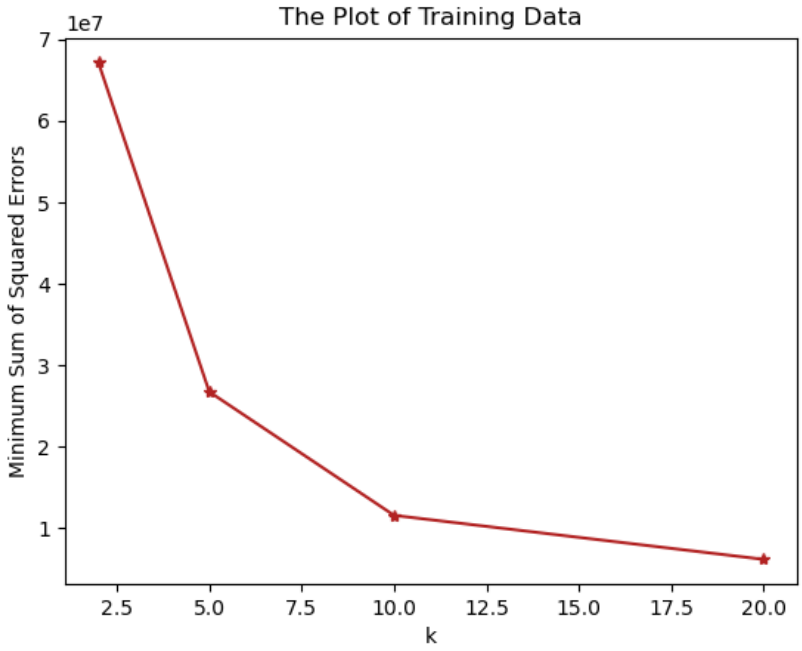
```
D:\Courses\CMPT459\459 a5>q1.py
Initialization complete
Iteration 0, inertia 15410364.102699803
Iteration 1, inertia 12243840.407841481
Iteration 2, inertia 11929243.90783348
Iteration 3, inertia 11839955.53555544
Iteration 4, inertia 11792778.72195906
Iteration 5, inertia 11774300.219585096
Iteration 6, inertia 11768412.409003872
Iteration 7, inertia 11760557.093353344
Iteration 8, inertia 11751260.437903449
Iteration 9, inertia 11742412.868928708
Iteration 10, inertia 11736807.110710341
Iteration 11, inertia 11731831.846357357
Iteration 12, inertia 11726371.269059962
Iteration 13, inertia 11718958.806400403
Iteration 14, inertia 11711761.70888541
Iteration 15, inertia 11705159.847115891
Iteration 16, inertia 11699285.905108016
Iteration 17, inertia 11691740.16299562
Iteration 18, inertia 11685886.243646884
Iteration 19, inertia 11681660.527468475
Iteration 20, inertia 11676708.15854409
Iteration 21, inertia 11673051.946298866
Iteration 22, inertia 11667143.679287773
Iteration 23, inertia 11660831.369200733
Iteration 24, inertia 11654831.876941053
Iteration 25, inertia 11652146.502023159
Iteration 26, inertia 11650668.255109815
Iteration 27, inertia 11649238.411643554
Converged at iteration 27: center shift 0.4945949936045934 within tolerance 0.6309756824730974
```



It is obvious that as iteration number increases, the sum of squared errors decreases. When the iteration is large enough, the curve of sum of squared errors become smooth and slow. The result of an iteration will be used for update the model as the initial parameters of the next iteration, which will improve the model accuracy. And the sum of squared errors can be used as a measure of variation. That's why iteration number increases while the sum of squared errors decreases.

Question 2

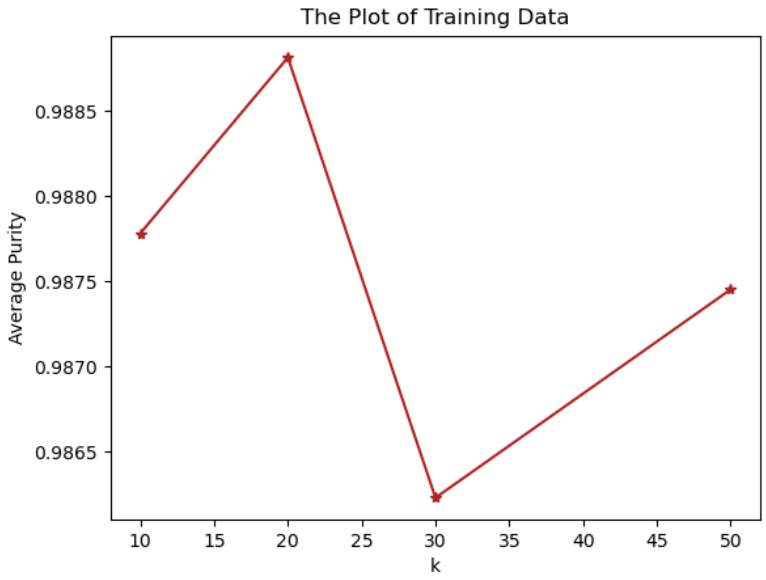
k = 2, Minimum SSE: 67193645.32656775
k = 5, Minimum SSE: 26724891.416540697
k = 10, Minimum SSE: 11536048.454204438
k = 20, Minimum SSE: 6129890.485943997



The plot shows that the value of the sum of squared errors is declined. As k increases, the minimum sum of squared errors decreases. With the number of clusters increasing, the points in each cluster become fewer and the points are closer to the centroid which means the minimum sum of squared errors is reduced.

Question 3

k = 10, Average purity: 0.9877818113298724
k = 20, Average purity: 0.9888152287484223
k = 30, Average purity: 0.9862287585276618
k = 50, Average purity: 0.9874526055286303

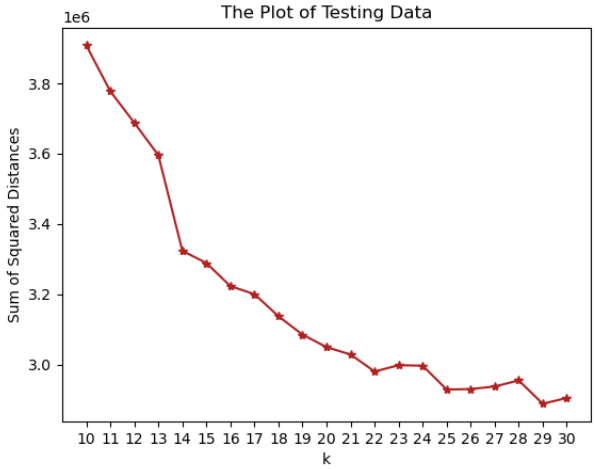


The average purities are very close. The average purity first increases and declines later and rises finally. When $k = 20$, it has the highest average purity. At this point, the cluster has a good appearance. When $k = 30$, it has the lowest average purity. When $k > 30$, the purity increases, but it does not mean the k value is suitable. That is because when the k value is too large, a large amount of information is scattered into many clusters, which makes the algorithm useless.

Question 4

For this question I modified the return value of the $predict()$ function in the KMeans class in the Scikit-learn k-means source code to get SSD value for each k.

k = 10, SSD: 3908476.248153473
k = 11, SSD: 3777783.4772540205
k = 12, SSD: 3688159.3097920525
k = 13, SSD: 3595605.3208252597
k = 14, SSD: 3323540.875105435
k = 15, SSD: 3288707.340516205
k = 16, SSD: 3222901.4116226397
k = 17, SSD: 3200275.039078066
k = 18, SSD: 3137258.7898213086
k = 19, SSD: 3084990.231775161
k = 20, SSD: 3049447.3537196205
k = 21, SSD: 3028463.1059480985
k = 22, SSD: 2980056.6311656325
k = 23, SSD: 2997876.3018657914
k = 24, SSD: 2996632.044139963
k = 25, SSD: 2928745.0413606092
k = 26, SSD: 2930120.2258050363
k = 27, SSD: 2937364.177074828
k = 28, SSD: 2954729.741762808
k = 29, SSD: 2888231.450473497
k = 30, SSD: 2904736.8478344525



When $k = 29$, it has minimum SSD, 2888231.450473497. Therefore, the best value of k is 29.s