

Lin Yang

## Problem 1:

(1) The result of the computed minimum-spanning tree and the total distance on it

The result of the computed minimum-spanning tree is

Node	Node	Distance
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79	205	16
1697	1832	20
1617	1919	21
1317	1316	25
1399	1062	25
477	511	25
1117	1119	26
188	157	27
404	50	27
1730	1753	27
1912	1926	27
1167	1266	27
1188	1189	27
1494	927	29
1312	947	30
180	506	30
1616	1077	30
1231	1232	30

1427	1428	31
1440	1147	31
1627	1847	31
485	504	31
394	503	32
843	1006	32
1465	1466	33
98	60	33
752	780	33
429	239	33
1476	946	34
1694	1881	34
1039	1155	34
718	1583	35
1540	1541	35
1615	1202	35
1068	1249	36
1018	1171	37
1584	1607	38
1641	1643	38
1726	1727	38
1909	1922	38
1159	1160	38

1326	1243	40
1501	1505	40
1754	1844	40
195	198	42
1926	557	42
1962	1127	42
773	774	43
1685	1686	43
1918	584	43
989	1251	43
1606	1066	44
868	965	44
347	282	45
451	464	45
765	563	46
100	463	46
469	243	46
1342	1073	47
1415	1450	47
1578	1640	47
1741	1986	47
490	502	47
611	1246	48

1420	1421	49
681	736	50
1318	1319	50
1331	1380	50
730	878	51
1892	1213	51
1375	972	52
1543	824	52
1573	1303	52
1228	1227	52
694	830	53
20	21	53
1629	1015	53
94	114	54
411	533	54
712	714	55
353	446	56
1673	1866	56
1787	1976	56
340	452	57
1745	1843	57
489	501	57
1391	1301	58

1405	1535	58
347	384	58
1487	1219	58
748	782	58
1710	1752	58
1807	1903	58
905	980	58
1157	1155	58
160	407	59
1469	1566	59
1558	1270	59
809	609	60
838	837	60
1286	1287	60
357	494	61
869	1080	61
899	900	61
476	145	62
1635	1829	63
1900	1300	63
1083	1255	63
589	1253	63
1703	1702	64

1385	1386	65
190	287	67
1789	615	67
961	962	67
1039	1040	67
1327	1331	68
1475	1626	68
778	777	68
1770	1863	68
1329	1409	69
904	935	69
618	619	69
4	5	70
713	773	70
1422	1423	70
530	315	71
1515	824	72
1805	1873	72
713	1257	73
1683	1021	73
1749	1826	74
549	1275	74
737	1060	75

1922	1281	75
1383	1515	76
1385	1389	76
1441	549	76
390	261	76
1666	1764	76
1930	1252	76
1954	1069	76
538	536	77
702	619	78
895	1040	78
956	957	79
1233	1234	79
1353	1622	80
1624	1236	80
1813	1862	80
1236	1237	80
1349	859	81
1726	1767	81
465	468	81
808	990	82
425	462	82
1892	1215	82

1311	1393	83
1415	1272	83
519	265	84
1417	1191	85
387	388	85
49	123	85
230	231	85
471	470	85
98	70	86
1614	1621	87
817	901	87
401	466	87
221	492	87
704	705	88
1416	1418	88
1457	1589	88
1403	1404	89
949	978	89
1949	1080	89
475	505	89
566	599	89
1101	1102	89
280	281	89

1531	774	90
1178	1179	90
322	74	91
1436	1845	91
1866	1867	91
1404	1795	92
1405	1499	92
1844	1846	92
1894	985	92
1535	1561	93
91	34	93
1621	1200	93
201	52	93
878	1013	93
883	1285	93
504	505	93
1311	1216	94
828	842	94
1820	1837	94
505	506	94
1710	1711	95
1876	1877	95
1342	1113	96

1421	1520	96
396	253	96
106	33	96
1100	1101	96
778	1285	97
105	71	97
1768	1799	97
894	967	97
32	69	97
1469	1502	98
47	66	98
780	999	98
783	888	98
193	263	98
1579	1635	98
1001	1003	98
1048	1159	98
1349	1748	100
818	1251	101
423	313	101
875	961	101
889	1013	101
14	15	101

1117	1118	101
345	346	102
1623	1926	102
1347	1913	103
182	407	103
842	1011	103
540	1299	103
1394	1023	104
1616	1894	104
1679	1839	104
219	220	104
1009	1012	104
257	282	104
722	557	105
843	655	105
1900	561	105
1119	1162	105
321	152	106
1580	1823	106
850	639	106
989	1014	106
1104	1103	106
295	296	106

1243	1242	106
1441	1899	107
408	461	107
1693	1882	107
1786	1847	107
167	166	108
768	769	108
281	291	108
601	1230	108
1355	1623	109
1470	1895	109
1734	1915	109
219	266	109
1906	1020	109
1319	777	110
171	276	110
799	618	110
195	196	110
449	450	110
178	136	111
208	135	111
1737	1791	111
877	878	111

437	119	111
946	945	111
71	72	111
1250	641	111
1457	598	112
1572	1966	112
1599	908	112
1629	1748	112
430	308	112
880	930	112
515	76	112
549	548	112
614	617	112
1338	1587	113
1344	1346	113
1406	562	113
1582	1628	113
99	510	113
829	830	113
834	1838	113
1729	1858	113
1904	962	113
1062	1063	113

1170	1171	113
705	1938	114
344	408	114
92	93	114
447	452	114
1955	1092	114
1201	1205	114
1443	1450	115
365	30	115
767	554	115
1593	1022	115
1688	1978	115
414	307	115
1806	1915	115
303	307	115
682	1131	116
176	152	116
548	603	116
721	556	117
360	262	117
383	294	117
1630	551	117
893	977	117

1811	1022	117
1053	1265	117
284	310	117
714	611	118
361	363	118
1626	626	118
1706	1861	118
894	932	118
515	75	118
1088	1137	118
291	294	118
641	642	118
666	844	119
1351	1399	119
1440	1141	119
1481	763	119
372	158	119
1700	564	119
910	911	119
466	292	119
640	644	119
1316	1409	120
327	229	120

686	831	120
1624	1625	120
1632	1649	120
201	209	120
891	1015	120
554	1280	120
1086	1105	120
1098	1130	120
348	461	121
1499	1146	121
55	124	121
1087	1134	121
1281	1282	121
1328	1896	122
695	1249	122
1392	1391	122
1631	1266	122
414	209	122
972	1232	122
1037	1155	122
348	349	123
349	396	123
733	969	123

1494	931	123
1603	1796	123
1618	1619	123
413	509	123
910	551	123
1909	1164	123
467	292	123
491	523	123
606	608	123
1403	1187	124
1432	1524	124
1441	1244	124
1480	1486	124
764	883	124
1633	1652	124
401	290	124
1650	1829	124
421	298	124
881	930	124
945	1227	124
1581	599	125
1600	1786	125
392	235	125

1681	1823	125
1781	1975	125
283	284	125
1202	1203	125
644	648	125
164	165	126
1352	1279	126
1427	1560	126
727	757	126
1914	1601	126
1464	1969	126
788	642	126
395	265	126
1619	1109	126
1654	1830	126
1662	1980	126
1733	1857	126
897	898	126
1928	567	126
1932	586	126
539	540	126
1368	716	127
1374	1426	127

707	709	127
1439	1062	127
739	1652	127
741	1644	127
763	1302	127
389	397	127
820	1052	127
1656	1977	127
1676	1723	127
208	151	127
422	299	127
109	110	127
974	643	127
1313	1400	128
1390	1435	128
1390	1442	128
709	638	128
716	1522	128
721	861	128
1514	1106	128
187	429	128
385	386	128
1582	996	128

193	194	128
800	637	128
1658	1687	128
1698	1803	128
210	306	128
1772	1797	128
988	989	128
248	283	128
1028	1032	128
1061	1227	128
555	1279	128
1092	589	128
1124	1126	128
1194	1208	128
1224	1225	128
1315	1179	129
336	143	129
1401	1050	129
1446	1521	129
1493	1586	129
368	261	129
776	1186	129
819	1177	129

23	293	129
1643	1941	129
833	1864	129
1661	1662	129
1708	1725	129
1762	1988	129
472	8	129
126	127	129
1057	1116	129
1059	1058	129
135	136	129
141	142	129
1195	1277	129
668	1257	130
741	1785	130
775	1145	130
191	273	130
1562	1563	130
1594	1595	130
1656	1658	130
1675	1855	130
1675	1676	130
418	264	130

249	150	130
577	621	130
1193	1194	130
1340	1115	131
1344	1110	131
164	131	131
718	719	131
1428	1431	131
1536	1563	131
1645	1744	131
1663	1664	131
202	205	131
1765	1871	131
1816	1842	131
224	153	131
976	1197	131
237	245	131
1063	1198	131
578	592	131
67	313	131
1165	1166	131
607	636	131
1186	1187	131

1222	1224	131
1270	1271	131
1359	1298	132
1362	1363	132
1364	1365	132
81	352	132
1373	1382	132
1435	1583	132
1440	1196	132
354	139	132
1462	821	132
361	369	132
368	147	132
1507	1508	132
1570	1292	132
1571	822	132
1581	1974	132
814	638	132
1680	1800	132
872	1012	132
893	902	132
1024	552	132
1030	1051	132

1046	1156	132
1064	1238	132
1095	622	132
604	1184	132
1296	1297	132
1315	1256	133
681	1128	133
327	227	133
1379	1402	133
1382	1542	133
1459	1291	133
1460	1471	133
1461	1472	133
1467	534	133
743	744	133
745	779	133
1490	1491	133
751	753	133
1797	1798	133
774	1246	133
1542	1041	133
1550	1654	133
1577	1580	133

1610	1771	133
1631	1976	133
1633	1655	133
1647	1906	133
835	623	133
867	553	133
1774	1972	133
929	1207	133
992	1086	133
535	1262	133
1081	1111	133
1118	1282	133
1122	625	133
1145	1146	133
1171	605	133
1277	1278	133
1313	928	134
1320	814	134
1358	1185	134
1364	1533	134
1377	1378	134
1387	1169	134
1410	1170	134

712	631	134
1411	1412	134
1449	1042	134
735	759	134
363	532	134
1491	1523	134
1507	1794	134
1539	1095	134
1551	1830	134
191	404	134
800	631	134
811	575	134
1622	1623	134
1632	1634	134
873	1011	134
224	225	134
1862	1985	134
236	527	134
525	295	134
1173	1175	134
606	635	134
1207	1208	134
1263	1264	134

673	1005	135
1332	1198	135
166	168	135
169	170	135
1398	1442	135
1429	1525	135
1452	1453	135
733	1891	135
1454	1554	135
734	738	135
1459	1460	135
1461	1570	135
1471	1549	135
362	268	135
751	576	135
1498	1559	135
1504	1506	135
1509	1560	135
770	1649	135
770	1801	135
1549	1653	135
1552	1262	135
1552	1634	135

1571	534	135
1576	599	135
1609	1610	135
1639	1684	135
1686	1825	135
1735	1855	135
1740	1741	135
1807	1857	135
904	1905	135
1842	1869	135
924	950	135
975	1199	135
1018	593	135
1041	1042	135
1043	1269	135
1105	1211	135
578	622	135
1148	1150	135
1151	1152	135
597	1269	135
1183	1184	135
323	101	136
1366	1532	136

704	1165	136
1427	1530	136
1429	1498	136
1430	1454	136
1451	1559	136
732	847	136
1452	1488	136
732	760	136
1462	535	136
1467	1551	136
1474	1777	136
1490	1264	136
752	1077	136
1524	1188	136
1556	1557	136
1577	1578	136
1588	1609	136
194	227	136
1605	1178	136
821	597	136
1683	1691	136
857	1897	136
1783	1190	136

1794	1290	136
1803	1911	136
1839	1023	136
1043	621	136
62	63	136
1054	635	136
1111	1114	136
1162	1202	136
1189	1190	136
1222	1223	136
1241	1245	136
1384	577	137
708	742	137
710	711	137
1431	1433	137
1448	1488	137
1449	596	137
1459	1502	137
1463	1783	137
1508	1540	137
186	28	137
1516	1536	137
1523	1539	137

779	1240	137
1557	1567	137
1560	1288	137
46	47	137
822	596	137
824	823	137
418	131	137
1705	1725	137
1783	1289	137
1798	1974	137
901	1120	137
474	269	137
490	491	137
1019	1283	137
1273	1274	137
1290	1291	137
321	214	138
1363	593	138
1364	1532	138
1366	1367	138
1367	1559	138
1383	1541	138
1428	1289	138

1445	1446	138
1451	1556	138
735	825	138
746	867	138
1525	1555	138
386	103	138
202	204	138
203	229	138
1722	1723	138
1779	1958	138
900	1115	138
901	1057	138
463	483	138
1019	592	138
1147	1149	138
1292	1293	138
165	168	139
1363	1489	139
1368	1273	139
170	235	139
1433	1489	139
734	826	139
1501	1504	139

1521	1530	139
1572	1189	139
1628	998	139
1684	1743	139
1696	1758	139
1777	1142	139
443	118	139
976	1064	139
991	1129	139
1024	1180	139
1056	1084	139
151	316	139
671	672	140
672	827	140
1340	588	140
1351	625	140
1424	1283	140
1453	1609	140
736	1867	140
1470	1471	140
1513	1724	140
1529	1540	140
1590	1730	140

1600	920	140
1668	1252	140
1778	1276	140
915	546	140
1840	1849	140
225	234	140
951	953	140
547	639	140
1072	1250	140
267	268	140
1209	1211	140
1366	1522	141
86	516	141
1473	1224	141
360	380	141
395	420	141
1690	1692	141
1694	1722	141
1705	1856	141
1773	1774	141
1866	1902	141
231	277	141
1933	629	141

966	1035	141
579	1235	141
1140	1141	141
1324	1298	142
1408	1296	142
10	397	142
742	975	142
1501	1290	142
767	556	142
771	772	142
379	196	142
23	24	142
1712	1759	142
1760	1879	142
109	121	142
928	929	142
1029	1052	142
1071	1074	142
1212	1280	142
1214	1223	142
1314	1484	143
1321	1323	143
1322	1324	143

1339	1255	143
326	200	143
1357	1358	143
333	302	143
1372	1426	143
167	228	143
337	237	143
1438	1275	143
768	546	143
770	1940	143
95	389	143
1588	598	143
13	127	143
1713	1738	143
1755	1851	143
952	953	143
1014	1265	143
1027	1028	143
1323	1402	144
1348	722	144
328	205	144
81	54	144
1378	1153	144

85	48	144
1412	1424	144
715	630	144
350	352	144
1483	1139	144
187	188	144
1548	1971	144
1592	1731	144
199	277	144
1696	1697	144
416	236	144
1925	1802	144
1837	569	144
1067	1217	144
1094	1127	144
1152	1154	144
1174	1229	144
1176	1177	144
1335	1027	145
1337	1050	145
1337	1336	145
1371	1424	145
1371	1372	145

1386	1434	145
1388	772	145
1408	1425	145
1434	600	145
1483	1141	145
370	371	145
377	412	145
1592	1755	145
1659	1704	145
1699	1718	145
1829	1830	145
1030	1031	145
266	311	145
1173	1174	145
1176	1229	145
1294	1295	145
1321	1153	146
1322	1154	146
1335	1031	146
1336	1029	146
1354	1356	146
1357	1425	146
1396	1397	146

729	844	146
1473	1474	146
1505	1538	146
1615	1247	146
1729	1735	146
1732	1832	146
1738	1739	146
1758	1882	146
1792	1295	146
1841	1853	146
1851	1852	146
956	1949	146
126	317	146
1075	1076	146
580	1207	146
1360	1361	147
1419	1096	147
716	810	147
183	37	147
1511	1512	147
1528	600	147
771	591	147
93	518	147

1590	1591	147
820	1032	147
1712	1713	147
1761	1762	147
1766	1805	147
1934	595	147
1148	1184	147
80	193	148
1370	717	148
1397	1810	148
1419	1782	148
744	1168	148
1519	1782	148
1548	1306	148
198	207	148
1689	1690	148
1699	1700	148
220	153	148
943	1158	148
947	948	148
1919	1079	148
482	245	148
254	293	148

1074	1075	148
154	155	148
1322	1425	149
1339	1254	149
1378	1030	149
1414	1458	149
345	396	149
758	646	149
1512	1737	149
1586	1304	149
1608	1613	149
1669	1802	149
409	475	149
213	215	149
214	460	149
1765	1872	149
1096	1097	149
1147	1148	149
1304	1307	149
1311	1231	150
318	275	150
1317	630	150
1323	1324	150

1341	1055	150
336	217	150
1396	1704	150
45	95	150
362	149	150
755	645	150
1516	1517	150
1517	1782	150
1574	1575	150
195	197	150
1727	1763	150
1764	1878	150
1809	1854	150
1931	651	150
1073	1159	150
8	9	150
1203	1220	150
667	750	151
669	670	151
1361	1373	151
1369	1370	151
341	36	151
354	2	151

1520	1574	151
1544	560	151
1599	934	151
1604	1256	151
1629	877	151
1669	1670	151
1707	1768	151
1818	1827	151
1834	573	151
541	1121	151
137	138	151
617	647	151
1303	1304	151
319	244	152
1341	1254	152
329	206	152
1357	1424	152
687	750	152
687	1034	152
1413	1271	152
1420	545	152
350	351	152
1466	1568	152

1519	1307	152
1545	1575	152
1617	1618	152
1717	1874	152
1739	1850	152
1792	1793	152
1827	1828	152
1924	545	152
472	473	152
544	1097	152
63	78	152
1128	1132	152
1340	1112	153
739	740	153
206	207	153
1706	1746	153
1716	568	153
1724	1984	153
1775	1815	153
1853	1868	153
612	613	153
1360	1380	154
1370	1286	154

335	41	154
699	700	154
1492	1503	154
1731	1747	154
875	876	154
243	155	154
528	276	154
669	610	155
1665	1666	155
692	916	155
1410	1183	155
1413	1305	155
344	343	155
1482	1624	155
765	590	155
802	803	155
202	77	155
1664	1836	155
1665	1799	155
1678	1874	155
1682	1689	155
1709	1770	155
1732	1733	155

1852	1880	155
1896	1897	155
1936	615	155
255	288	155
538	613	155
147	148	155
613	632	155
1326	540	156
329	216	156
715	610	156
1422	1584	156
1476	1242	156
754	1002	156
1579	1742	156
1648	1021	156
1707	1734	156
1660	1854	156
1708	1709	156
1708	1767	156
1769	1800	156
1814	1880	156
232	233	156
1305	1306	156

670	632	157
1793	1865	157
173	306	157
176	226	157
1511	1751	157
375	380	157
1537	1538	157
383	289	157
1749	1828	157
1790	1818	157
238	255	157
465	289	157
254	256	157
674	725	158
1414	1518	158
1423	1895	158
1456	1566	158
749	781	158
1533	1553	158
381	447	158
870	661	158
215	460	158
223	304	158

1808	1763	158
914	926	158
1935	607	158
128	129	158
1199	1258	158
667	749	159
675	925	159
1334	1930	159
913	848	159
726	756	159
729	1478	159
177	213	159
178	216	159
1484	1209	159
1489	1510	159
366	367	159
813	852	159
427	436	159
1785	634	159
1848	1850	159
481	512	159
1008	514	159
1059	1156	159

1259	1267	159
662	663	159
318	337	160
680	804	160
1343	696	160
78	131	160
684	955	160
688	689	160
1444	1503	160
761	1144	160
370	428	160
376	417	160
793	794	160
1596	1597	160
1627	1628	160
1644	1646	160
853	854	160
1804	1703	160
444	477	160
922	986	160
244	245	160
582	650	160
1318	1268	161

679	680	161
678	664	161
679	691	161
683	922	161
689	697	161
693	657	161
697	698	161
698	812	161
181	158	161
762	650	161
4	409	161
373	398	161
1521	1534	161
92	239	161
182	242	161
378	241	161
381	130	161
805	1942	161
806	855	161
815	816	161
401	473	161
1659	1875	161
431	240	161

909	1144	161
914	959	161
241	242	161
1024	1241	161
604	1182	161
1181	1182	161
1198	1239	161
677	683	162
336	142	162
703	651	162
1837	1836	162
912	979	162
728	924	162
1458	587	162
1492	1493	162
373	374	162
1553	1168	162
1594	1680	162
806	581	162
1638	633	162
412	474	162
223	37	162
925	940	162

118	160	162
552	604	162
553	605	162
560	561	162
568	569	162
1178	1208	162
1181	1195	162
1239	1240	162
1259	1260	162
654	657	162
660	661	162
1314	1175	163
674	662	163
1330	1268	163
1376	1267	163
700	791	163
346	145	163
347	317	163
728	729	163
1447	745	163
88	89	163
1479	1276	163
1526	1527	163

789	816	163
392	77	163
944	943	163
852	955	163
764	585	163
211	212	163
52	232	163
1856	1861	163
1914	986	163
1822	1865	164
1343	703	164
1345	1788	164
812	856	164
685	690	164
691	653	164
693	855	164
694	695	164
1377	1149	164
696	659	164
1447	1448	164
731	761	164
1477	959	164
181	427	164

117	374	164
369	378	164
791	792	164
805	854	164
815	1068	164
870	853	164
908	909	164
956	1035	164
1067	1237	164
278	279	164
675	676	165
321	334	165
678	726	165
684	665	165
793	813	165
1707	1981	165
376	398	165
1597	1639	165
434	222	165
227	228	165
158	159	165
1352	1963	166
167	192	166

762	916	166
1547	1607	166
795	804	166
851	1010	166
1596	1653	166
393	62	166
828	655	166
851	656	166
876	995	166
1769	1770	166
250	148	166
690	699	167
334	224	167
1595	1840	167
1465	1569	167
789	790	167
1614	1960	167
904	905	167
1814	1815	167
1944	1055	167
63	134	167
1223	1301	167
739	1742	168

1934	1877	168
375	428	168
848	849	168
431	156	168
890	891	168
53	151	168
441	154	168
676	845	169
692	658	169
432	149	169
38	51	170
685	846	170
723	756	170
724	725	170
175	67	170
1456	1585	170
1620	1123	170
832	653	170
423	105	170
426	240	170
881	882	170
444	454	170
983	1082	170

1056	1079	170
1310	1356	171
53	201	171
1527	561	171
731	840	171
403	51	171
405	406	171
1667	1172	171
840	665	171
841	660	171
217	218	171
1008	654	171
1061	1237	171
1075	1156	171
846	664	172
1585	1608	172
1710	1804	172
1763	1875	172
1838	594	172
991	1076	172
1087	1130	172
1314	1139	173
356	252	173

740	1681	173
439	75	173
1960	1102	173
1016	559	173
1120	1161	173
1137	1138	173
677	841	174
339	377	174
1868	1812	174
832	663	174
874	875	174
912	913	174
998	550	174
711	637	174
1099	1133	174
1123	1172	174
688	845	175
1381	1531	175
44	279	175
183	50	175
159	442	175
810	611	175
1672	1120	175

849	658	175
1813	1812	175
1133	1172	175
1893	1756	176
1753	1846	176
892	931	176
926	1008	176
536	537	176
142	287	176
601	602	176
320	57	177
730	829	177
114	115	177
982	1083	177
991	992	177
7	18	177
1087	1088	177
278	143	177
338	339	178
379	305	178
1685	1870	178
836	937	178
1666	1898	178

1959	1167	178
258	259	178
783	782	179
1630	939	179
1781	1179	179
1047	1098	179
291	292	179
1332	1278	180
949	1905	180
1699	1701	180
391	445	180
439	26	180
938	936	180
1338	1248	181
1475	1209	181
747	787	181
1591	1841	181
11	107	181
1016	1017	181
1049	1099	181
1173	1210	181
211	405	182
1124	1177	182

1528	1270	182
101	102	183
1698	564	183
1739	1792	183
108	448	183
457	1000	183
133	134	183
1125	1229	183
1158	1248	183
338	424	184
403	150	184
430	432	184
1808	1872	184
1890	500	184
958	957	184
512	528	184
1053	1054	184
550	551	184
1076	1130	184
643	644	184
1746	1754	185
829	1006	185
559	1135	185

1123	1124	185
1201	1230	185
1543	1299	186
1569	537	186
1849	1893	186
460	503	186
1788	1038	186
1331	1033	187
1345	1110	187
1390	1260	187
1864	594	187
1010	1034	187
1093	1110	187
1132	1225	187
1759	1863	187
169	212	188
0	76	188
1776	1775	188
1890	457	188
1104	1105	188
627	628	188
1482	1206	189
1495	775	189

1777	1217	189
325	197	190
1394	1395	190
1439	1778	190
1513	1711	190
836	964	190
997	1085	190
1643	1644	191
433	440	192
918	1026	192
260	137	192
238	482	193
997	998	193
747	920	194
521	129	194
1249	656	194
9	120	195
341	211	195
191	190	195
1822	1817	195
748	882	196
1573	587	196
1106	1107	196

1518	1561	197
862	1089	197
863	1166	197
1935	609	197
539	570	197
32	31	197
981	982	198
162	301	199
781	984	199
146	249	199
107	366	199
1859	1752	199
54	55	199
1089	1090	199
1093	1094	199
1309	1308	200
1349	942	200
1392	1233	200
1407	1500	200
353	262	200
386	463	200
1009	842	200
274	275	200

667	981	201
319	179	201
1455	1611	201
737	1939	201
89	129	201
983	984	201
326	185	202
1645	1766	202
895	1901	202
104	246	202
501	502	202
1037	1038	202
1230	1284	202
933	890	203
437	450	203
1886	1885	203
1920	1921	203
1284	1033	203
144	145	203
1375	1376	204
701	543	204
1458	1565	204
391	272	204

1780	1218	204
1565	1305	205
957	1114	205
163	33	206
839	869	206
448	12	206
917	547	206
1564	1413	206
165	186	207
1423	633	207
1979	1662	207
819	601	207
1218	1219	207
39	438	208
1437	1736	208
1444	718	208
1568	1567	208
1864	1728	208
1885	646	208
320	270	209
96	21	209
944	1253	209
898	896	209

796	1916	209
31	301	209
26	10	209
82	76	210
333	478	210
116	440	210
388	399	210
919	1947	210
56	34	210
30	300	210
172	184	211
1686	1640	211
233	526	211
1912	555	211
316	146	211
1136	1223	211
38	37	212
382	97	213
899	958	214
437	128	214
117	453	214
384	259	214
1390	776	215

402	451	215
895	896	215
1715	1843	215
25	433	215
19	292	216
1250	643	216
384	14	217
942	941	217
1325	570	217
1109	1108	217
1714	1826	217
1496	1526	218
817	862	218
1873	1860	218
1958	1096	218
1961	1107	218
1714	1764	219
1344	618	220
721	628	220
737	1091	220
836	936	220
1859	1660	220
498	499	220

177	408	221
1603	1436	221
104	273	221
439	438	221
1	0	222
11	300	222
12	301	222
222	308	222
1821	1715	222
57	56	222
30	31	222
1308	1407	223
16	310	223
1193	1244	223
163	445	224
1261	1070	224
1651	1691	224
1639	1650	224
1807	1898	224
969	993	224
286	285	225
1487	1234	225
906	950	226

1810	1883	226
82	40	227
1615	1090	227
907	923	227
1907	1921	227
236	263	227
1765	1686	228
858	890	228
329	394	229
1437	1761	230
1694	1695	230
1744	1743	230
960	995	230
484	61	230
973	1330	231
524	156	231
1058	1160	231
101	103	233
1888	1951	234
478	66	234
1564	1272	235
1636	1671	235
887	927	235

1651	1657	236
1310	1485	236
784	932	236
818	863	236
936	1085	236
1478	970	236
1916	807	236
73	74	236
977	892	237
1212	1213	237
728	871	238
633	634	238
640	649	238
871	923	239
355	5	239
185	192	239
1546	1468	239
1071	1163	239
579	1164	239
172	64	240
177	364	240
1460	1461	240
839	1108	240

902	903	240
970	994	240
459	73	241
1045	1122	241
337	282	242
488	489	242
58	509	242
1044	1072	242
1070	1071	242
648	652	243
1353	1354	243
84	125	243
449	440	243
1455	1613	243
1945	903	243
871	831	243
954	967	243
970	1007	243
1084	1161	243
801	884	244
766	554	244
838	1079	244
619	649	244

833	1735	245
1069	1112	246
915	542	247
980	995	247
124	125	247
1611	1612	248
1693	1702	248
334	480	248
1887	987	248
1036	899	248
667	666	249
1481	1122	249
1044	1045	249
43	44	250
357	73	250
1496	1497	250
1673	860	250
68	67	251
917	543	251
447	471	252
371	251	252
1545	1303	253
786	785	253

28	27	254
1845	1846	254
965	966	254
451	72	254
702	542	256
1406	1497	256
97	72	256
1907	1164	256
375	148	257
366	465	257
1913	1673	257
1881	1831	257
248	252	257
1642	1719	258
1671	1831	258
17	226	258
1002	1003	258
558	559	258
1351	1238	259
343	16	259
807	990	259
434	435	259
1931	582	259

837	836	260
1746	1747	260
382	25	260
446	494	261
866	636	261
1544	1543	262
487	993	262
522	138	262
64	28	262
295	74	262
42	236	263
1641	1721	263
564	1719	263
330	259	264
801	802	264
161	288	265
1649	1652	265
203	202	265
1443	765	266
351	312	266
422	421	266
320	26	267
753	847	268

1601	908	268
415	529	268
585	586	268
252	296	268
488	18	269
355	288	270
1197	1199	270
1393	1017	271
352	29	271
1546	1637	271
1891	999	271
529	305	271
41	42	272
1733	1745	273
120	520	273
885	887	274
271	297	274
459	385	275
1468	1192	276
293	352	276
479	367	277
1721	1720	277
1771	1554	277

963	1587	278
29	3	278
389	271	279
238	256	279
1674	1780	280
415	235	280
493	426	280
422	467	281
1740	1862	282
111	113	282
346	265	283
1681	1682	283
95	354	284
20	154	285
978	785	285
1658	1978	286
112	111	286
1094	1265	286
832	514	287
1589	566	287
331	59	287
960	1085	287
1901	1904	288

1701	1721	289
110	314	289
984	1616	289
330	299	290
1205	1204	290
121	112	290
1780	620	290
272	298	290
139	29	292
1036	1248	292
342	278	293
93	243	293
477	453	294
1716	1717	295
60	61	297
886	921	298
423	470	298
682	1128	298
113	315	298
671	1143	299
1398	883	299
706	517	299
112	520	299

857	637	300
472	400	300
1662	1718	300
1784	1783	300
335	425	301
736	1917	301
967	968	301
1333	1100	301
189	197	301
1677	1716	301
595	594	302
169	309	303
44	286	304
1918	949	306
390	410	307
927	921	307
1968	1547	308
1671	1350	308
446	411	309
332	357	309
1987	1750	309
985	1789	309
458	295	311

199	200	311
1348	861	311
1200	1201	311
324	303	313
48	49	313
495	498	313
1480	1674	314
335	140	314
100	99	314
1819	1790	314
1168	1169	314
314	455	315
17	65	315
497	16	316
1663	1768	316
99	59	316
783	920	317
1078	583	319
1003	1004	319
807	581	320
35	311	321
705	636	322
507	508	323

498	497	323
496	247	324
792	798	325
1191	1192	331
1787	1060	334
1911	1858	335
668	1320	336
133	132	336
1065	1217	336
738	759	337
825	847	337
808	582	338
424	419	338
1026	1135	339
751	752	339
362	474	340
6	7	341
160	374	344
5	276	344
496	497	344
947	1017	346
884	886	347
342	531	348

590	591	352
1612	1308	355
673	672	357
787	879	359
701	652	360
399	468	360
1370	669	366
402	2	367
1255	1347	369
1776	1869	369
342	484	369
518	493	371
369	436	371
571	572	372
1889	1890	373
358	363	374
372	156	375
647	1091	376
827	826	376
1952	1025	377
990	1026	377
556	720	378
1417	1416	378

566	567	378
1910	1602	379
413	508	380
676	664	381
971	803	388
250	432	388
122	124	389
673	727	393
1835	1834	395
572	1395	398
46	7	399
1879	1736	399
545	1925	401
939	951	402
722	835	403
1415	1192	405
755	754	406
1647	1648	406
903	954	406
558	624	408
793	789	412
380	417	412
645	646	412

1350	1020	412
184	138	413
571	1593	413
469	114	413
1886	1005	413
173	247	414
1789	1121	415
683	675	416
221	419	419
1811	1835	419
1657	1656	419
1157	1598	423
1603	1761	428
49	70	429
723	724	431
1947	1216	431
647	616	432
1568	1973	435
892	882	436
1554	1555	439
624	623	439
1203	1438	440
1951	987	450

574	1679	454
122	123	456
1221	1220	458
573	1651	468
486	174	473
968	1948	475
1167	1102	482
1752	1751	483
794	797	483
1514	1089	488
1066	1065	491
584	583	500
359	267	504
1884	1204	504
1952	1026	506
1956	1078	506
413	85	506
1756	1757	522
1226	706	525
455	456	534
1965	1263	539
579	1930	539
1490	1970	540

1774	1833	544
1883	1737	555
1950	978	563
1040	1953	582
115	486	589
523	140	594
811	614	595
1598	1602	597
1964	1235	601
1946	910	602
1458	629	616
1889	1887	617
90	89	621
440	86	629
1821	1989	638
1555	1972	642
864	1004	642
1983	1691	643
1908	1992	650
1855	1990	652
1463	1464	666
541	1923	669
87	516	693

20	513	733
656	1937	733
1824	1696	740
1987	1749	742
1001	1890	774
1004	706	779
866	865	780
1908	1637	780
83	90	842
565	1927	999
1674	1982	1013
1943	798	1031
1347	1967	1032
1927	1593	1178
1957	1091	1205
96	22	1208
1929	1395	1252
487	83	1395
1890	1991	3703

The total distance is 371466

## (2) The analysis of the memory usage by each data structure

The memory usage for two-dimensional array is 20,022,536 bytes and the memory usage for the program is 139,773,840 bytes. It is likely to see that Linked-List takes more memory usage than two-dimensional array. For each node in Linked-List contains two data types (vertexID and Distance) and two reference types (pre and next). Elements cannot be accessed at random in linked lists compared with two-dimensional array whose elements are stored in contiguous addresses.

## **Problem 2:**

### **(1) Test Case Dataset**

**The coordinates of each centroid**

**A count of the number of points assigned to each centroid**

**The losses for each iteration of training**

Iteration 0:

The coordinates of Centroid\_0 is (-2.2041123876525517, 2.3035988160134617)

The number of points assigned to centroid\_0 is 62

The coordinates of Centroid\_1 is (8.402100331099673, 6.187027648712632)

The number of points assigned to centroid\_1 is 138

The loss for the iteration of training is 54.857521732103514

Iteration 1:

The coordinates of Centroid\_0 is (-0.7162580398866999, -0.12122107441348128)

The number of points assigned to centroid\_0 is 88

The coordinates of Centroid\_1 is (9.695228438993984, 8.993753541638965)

The number of points assigned to centroid\_1 is 112

The loss for the iteration of training is 34.96421803924446

Iteration 2:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888, 10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 3:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888, 10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 4:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888, 10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 5:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 6:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 7:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 8:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 9:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 10:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 11:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 12:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 13:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 14:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 15:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 16:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 17:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 18:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 19:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 20:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 21:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 22:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 23:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 24:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 25:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 26:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 27:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 28:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

Iteration 29:

The coordinates of Centroid\_0 is (0.06026253328707723, -0.08038639294559319)

The number of points assigned to centroid\_0 is 100

The coordinates of Centroid\_1 is (10.168086243285888,10.046715814097372)

The number of points assigned to centroid\_1 is 100

The loss for the iteration of training is 30.96376193434194

## (2) Electric Power Consumption Dataset

**K = 2**

**The coordinates of each centroid**

**A count of the number of points assigned to each centroid**

**The losses for each iteration of training**

Iteration 0\_0:

The coordinates of Centroid\_0 is (1.3160192823473724, 0.13387101600636778, 239.72906662223068, 5.573598604736736, 1.460598950749724, 1.6045423756030512, 8.217464861968086)

The number of points assigned to centroid\_0 is 1569311

The coordinates of Centroid\_1 is (0.35790087693169237, 0.09050656188212831, 244.47171146469827, 1.535234567232445, 0.01458635870233286, 0.29794632570020146, 0.7071477532924001)

The number of points assigned to centroid\_1 is 479969

The loss for the iteration of training is 156.39990243487068

Iteration 0\_1:

The coordinates of Centroid\_0 is (2.0553605587036294, 0.14290482065735083, 239.29909293964533, 8.6358381474559, 2.76774221214813, 2.6832799338377185, 15.651202254418477)

The number of points assigned to centroid\_0 is 816175

The coordinates of Centroid\_1 is (0.4537253177951623, 0.11101265504562799, 241.85966886035376, 1.9748678336405585, 0.032578734171055994, 0.3819666613954205, 0.3738911122734885)

The number of points assigned to centroid\_1 is 1233105

The loss for the iteration of training is 102.5068151510022

Iteration 0\_2:

The coordinates of Centroid\_0 is (2.079330227515681, 0.1401626198897387, 239.48529120750337, 8.714011911776792, 2.9588805033312253, 2.5311460466897424, 17.12727694409124)

The number of points assigned to centroid\_0 is 741619

The coordinates of Centroid\_1 is (0.5314481796121128, 0.11438617501020884, 241.60807882933128, 2.310306570282616, 0.08012244763742285, 0.5994558222658625, 0.40779146888987283)

The number of points assigned to centroid\_1 is 1307661

The loss for the iteration of training is 95.92942651996492

Iteration 0\_3:

The coordinates of Centroid\_0 is (2.0689331442045766, 0.13962719062991152, 239.49670569048178, 8.668491831479592, 2.8180578552644393, 2.232524003473456, 17.399528367242514)

The number of points assigned to centroid\_0 is 728957

The coordinates of Centroid\_1 is (0.5520327707688115, 0.11492898631624018, 241.5814191376203, 2.3968504676525577, 0.18547885631016048, 0.7828516203989478, 0.4178212452558957)

The number of points assigned to centroid\_1 is 1320323

The loss for the iteration of training is 95.62304329120576

Iteration 0\_4:

The coordinates of Centroid\_0 is (2.0606063015001803, 0.13921083213893634, 239.50794094455622, 8.632972889215583, 2.6064536836687826, 2.1755131348123715, 17.542360945861443)

The number of points assigned to centroid\_0 is 722812

The coordinates of Centroid\_1 is (0.5635973879503967, 0.11527028318814682, 241.565639231432, 2.4452592900863137, 0.31298078807781265, 0.8206334415907508, 0.4186591760977272)

The number of points assigned to centroid\_1 is 1326468

The loss for the iteration of training is 95.5376861085628

Iteration 0\_5:

The coordinates of Centroid\_0 is (2.0536501041248423, 0.13879956512540675, 239.5176024405555, 8.603368190119491, 2.404958182992561, 2.1737229386609647, 17.64715855940131)

The number of points assigned to centroid\_0 is 718368

The coordinates of Centroid\_1 is (0.5723506467745003, 0.11557220612633379, 241.55355359335644, 2.4818997800020455, 0.4293972854704143, 0.8261237407131351, 0.4192711464018658)

The number of points assigned to centroid\_1 is 1330912

The loss for the iteration of training is 95.47497813326949

Iteration 0\_6:

The coordinates of Centroid\_0 is (2.0477265352316683, 0.1384877223378958,  
239.52505945313973, 8.578138859002829, 2.277888471265492, 2.1761237407257332,  
17.71106903827076)

The number of points assigned to centroid\_0 is 715690

The coordinates of Centroid\_1 is (0.5785042314354104, 0.11578620415570719,  
241.54546326085253, 2.507732061579665, 0.5015582000464911, 0.8275414482712078,  
0.4195682331151253)

The number of points assigned to centroid\_1 is 1333590

The loss for the iteration of training is 95.44498935914383

Iteration 0\_7:

The coordinates of Centroid\_0 is (2.0443789212309924, 0.13833866335221243,  
239.52946027962727, 8.563855249676307, 2.219290805157577, 2.1747960651919533,  
17.74096780153518)

The number of points assigned to centroid\_0 is 714444

The coordinates of Centroid\_1 is (0.5816674168212065, 0.11588717565304466,  
241.54122186548804, 2.521043483994915, 0.5345795288709624, 0.8295108912255887,  
0.41970624106631826)

The number of points assigned to centroid\_1 is 1334836

The loss for the iteration of training is 95.4370049442191

Iteration 0\_8:

The coordinates of Centroid\_0 is (2.0429965866482265, 0.13826020468906247, 239.53202251946257, 8.557873889469802, 2.1961927892419895, 2.174314843527868, 17.75261673956981)

The number of points assigned to centroid\_0 is 713961

The coordinates of Centroid\_1 is (0.582935595164866, 0.11593724645572148, 241.53912422427953, 2.5264273181178214, 0.5475388278006978, 0.8302547930494512, 0.4197431475175595)

The number of points assigned to centroid\_1 is 1335319

The loss for the iteration of training is 95.43565563428872

Iteration 0\_9:

The coordinates of Centroid\_0 is (2.042417978365487, 0.13823010525815452, 239.53301977252858, 8.55538136287753, 2.1868825908662326, 2.1740156829450425, 17.757266006228907)

The number of points assigned to centroid\_0 is 713769

The coordinates of Centroid\_1 is (0.5834547405449686, 0.11595654247700472, 241.53830268716692, 2.5286265706548, 0.5527517182561581, 0.8306079096315941, 0.41975019299728716)

The number of points assigned to centroid\_1 is 1335511

The loss for the iteration of training is 95.43544294722463

Iteration 0\_10:

The coordinates of Centroid\_0 is (2.0422266563542366, 0.13821778435379234,  
239.53336082366965, 8.554552154528219, 2.1842761585302632, 2.173683561578577,  
17.75876761579698)

The number of points assigned to centroid\_0 is 713706

The coordinates of Centroid\_1 is (0.5836257998433269, 0.11596417720022015,  
241.53802584509805, 2.529353970653636, 0.554221630549861, 0.8308487586610701,  
0.41976558393619523)

The number of points assigned to centroid\_1 is 1335574

The loss for the iteration of training is 95.43541726872724

Iteration 0\_11:

The coordinates of Centroid\_0 is (2.042156833897248, 0.13821307159322072,  
239.53341202353695, 8.554257130246139, 2.183234900551364, 2.1736312238592657,  
17.759278953599978)

The number of points assigned to centroid\_0 is 713685

The coordinates of Centroid\_1 is (0.5836860440477487, 0.11596704539924672,  
241.53796696606466, 2.5296063552212775, 0.5548036642844575, 0.8308978395396808,  
0.4197649736634234)

The number of points assigned to centroid\_1 is 1335595

The loss for the iteration of training is 95.43541438516772

Iteration 0\_12:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_13:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_14:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_15:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_16:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_17:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_18:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_19:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_20:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_21:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_22:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_23:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_24:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_25:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_26:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_27:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_28:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

Iteration 0\_29:

The coordinates of Centroid\_0 is (2.042141141688092, 0.13821265272952546,  
239.5334330792764, 8.55419039345325, 2.1829643537719985, 2.1736254343683443,  
17.759401972872997)

The number of points assigned to centroid\_0 is 713680

The coordinates of Centroid\_1 is (0.5836998891883451, 0.11596735250075395,  
241.53794821057284, 2.529664570231928, 0.5549543276430069, 0.830905959868224,  
0.41976415094339625)

The number of points assigned to centroid\_1 is 1335600

The loss for the iteration of training is 95.43541426062137

**For K from 3 to 20**

**A scatter plot containing the loss of the last iteration of training for each value of K**

**The coordinates of each centroid for each value of K**

**The number of points assigned to each centroid for each value of K**

**Using the elbow method (see Resources) find the value of K which best fits the data**

**K= 3:**

```
The coordinates of Centroid_0 are (4.037317732856577,0.1996569193188662, 237.12615782206893, 17.128859701915452,36.802262187134914,3.224165398095373,11.178532233511524)
The number of points assigned to centroid_0 are 56494
The coordinates of Centroid_1 are (1.9006639882725573,0.13441113742499108, 239.70843296202037, 7.946915433851091,0.2087564549936615,2.0289174840649857,17.836488779294317)
The number of points assigned to centroid_1 are 676027
The coordinates of Centroid_2 are (0.5498655866409856,0.11496456526974082, 241.58006604096923, 2.3873521274603156,0.05992212697995609,0.8409147004121483,0.4144258744386786)
The number of points assigned to centroid_2 are 1316759
The loss for the iteration of training is 58.0537029127163
```

The coordinates of Centroid\_0 are (4.037317732856577,0.1996569193188662,  
237.12615782206893, 17.128859701915452,36.802262187134914,3.224165398095373,  
11.178532233511524)

The number of points assigned to centroid\_0 is 56494

The coordinates of Centroid\_1 are (1.9006639882725573,0.13441113742499108,  
239.70843296202037, 7.946915433851091,0.2087564549936615,2.0289174840649857,  
17.836488779294317)

The number of points assigned to centroid\_1 is 676027

The coordinates of Centroid\_2 are (0.5498655866409856,0.11496456526974082,  
241.58006604096923, 2.3873521274603156,0.05992212697995609,0.8409147004121483,  
0.4144258744386786)

The number of points assigned to centroid\_2 is 1316759

The loss for the iteration of training is 58.0537029127163

**K= 4:**

```
The coordinates of Centroid_0 are (3.6932114212928417,0.1910311007324077, 237.7383874323345, 15.69863071860725, 0.8422672752361745, 35.523935887909985, 10.582167498142448)
The number of points assigned to centroid_0 are 47105
The coordinates of Centroid_1 are (3.99656026926329,0.1990934682049714, 237.17290861966578, 16.948098417898287, 36.94198959664501, 2.449990100613762, 11.15392645659693)
The number of points assigned to centroid_1 are 55559
The coordinates of Centroid_2 are (0.5199877041984787,0.11398875117402227, 241.61959836182322, 2.260452816826988, 0.05811405872299805, 0.41878088962108734, 0.4136945911407412)
The number of points assigned to centroid_2 are 1298980
The coordinates of Centroid_3 are (1.7997109765361443,0.1318588528123929, 239.81607245430635, 7.513770389539041, 0.20306314040603055, 0.4749102891130203, 17.879815204837286)
The number of points assigned to centroid_3 are 647636
The loss for the iteration of training is 30.338729461996895
```

The coordinates of Centroid\_0 are (3.6932114212928417, 0.1910311007324077,

237.7383874323345, 15.69863071860725, 0.8422672752361745, 35.523935887909985,

10.582167498142448)

The number of points assigned to centroid\_0 is 47105

The coordinates of Centroid\_1 are (3.99656026926329, 0.1990934682049714,

237.17290861966578, 16.948098417898287, 36.94198959664501, 2.449990100613762,

11.15392645659693)

The number of points assigned to centroid\_1 is 55559

The coordinates of Centroid\_2 are (0.5199877041984787, 0.11398875117402227,

241.61959836182322, 2.260452816826988, 0.05811405872299805, 0.41878088962108734,

0.4136945911407412)

The number of points assigned to centroid\_2 is 1298980

The coordinates of Centroid\_3 are (1.7997109765361443, 0.1318588528123929,

239.81607245430635, 7.513770389539041, 0.20306314040603055, 0.4749102891130203,

17.879815204837286)

The number of points assigned to centroid\_3 is 647636

The loss for the iteration of training is 30.338729461996895

**K= 5:**

```

coordinates of Centroid_0 are (3.698297517843814,0.19090064983487942, 237.73981271972136, 15.719254287844784,0.8441248535208267,35.58359433258762,10.610226909555768)
number of points assigned to centroid_0 are 46935
coordinates of Centroid_1 are (0.4005214282905037,0.10484404568154429, 243.42585895196166, 1.7383337117707653,0.025028953720981267,0.35523710338476294,0.42613407887843496)
number of points assigned to centroid_1 are 788327
coordinates of Centroid_2 are (1.7999017000207935,0.1318262719261088, 239.81619637135813, 7.514409472537053,0.20309263221311666,0.4755485869204211,17.88423483613838)
number of points assigned to centroid_2 are 647345
coordinates of Centroid_3 are (3.9977608358854098,0.19905022518465154, 237.174001981625, 16.952271662763664,36.9578814627995,2.4517744550531435,11.16319582057287)
number of points assigned to centroid_3 are 55510
coordinates of Centroid_4 are (0.7055094793636691,0.1281938090198315, 238.83079260432814, 3.0713881873301707,0.1110839399565305,0.5222013330385806,0.3996846407114756)
number of points assigned to centroid_4 are 511163
loss for the iteration of training is 26.858424406489366

```

The coordinates of Centroid\_0 are (3.698297517843814, 0.19090064983487942, 237.73981271972136, 15.719254287844784, 0.8441248535208267, 35.58359433258762, 10.610226909555768)

The number of points assigned to centroid\_0 is 46935

The coordinates of Centroid\_1 are (0.4005214282905037, 0.10484404568154429, 243.42585895196166, 1.7383337117707653, 0.025028953720981267, 0.35523710338476294, 0.42613407887843496)

The number of points assigned to centroid\_1 is 788327

The coordinates of Centroid\_2 are (1.7999017000207935, 0.1318262719261088, 239.81619637135813, 7.514409472537053, 0.20309263221311666, 0.4755485869204211, 17.88423483613838)

The number of points assigned to centroid\_2 is 647345

The coordinates of Centroid\_3 are (3.9977608358854098, 0.19905022518465154, 237.174001981625, 16.952271662763664, 36.9578814627995, 2.4517744550531435, 11.16319582057287)

The number of points assigned to centroid\_3 is 55510

The coordinates of Centroid\_4 are (0.7055094793636691, 0.1281938090198315, 238.83079260432814, 3.0713881873301707, 0.1110839399565305, 0.5222013330385806, 0.3996846407114756)

The number of points assigned to centroid\_4 is 511163

The loss for the iteration of training is 26.858424406489366

**K= 6:**

```
The coordinates of Centroid_0 are (2.5039500459551376,0.162286018349805, 237.07332419604916, 10.590452080343242,0.4665226201417891,0.7234897958086761,18.21791874271033)
The number of points assigned to centroid_0 are 186051
The coordinates of Centroid_1 are (1.5182378319445107,0.11981336690635107, 240.91914146528174, 6.284366482359599,0.10426455191271015,0.39088985800690496,17.741682458098627)
The number of points assigned to centroid_1 are 462276
The coordinates of Centroid_2 are (0.7050397154572775,0.12816193341890234, 238.8309410998368, 3.0693345802296323,0.11100959431540725,0.5232306079008326,0.3973776059600576)
The number of points assigned to centroid_2 are 511136
The coordinates of Centroid_3 are (3.702262252794489,0.19049127257093884, 237.74208039553102, 15.735472914875196,0.8496345657781599,35.73701633705933,10.558147033533963)
The number of points assigned to centroid_3 are 46520
The coordinates of Centroid_4 are (0.40038845690625946,0.10479865578467527, 243.42590367136643, 1.7377234383575002,0.025035248848622217,0.3552703215481827,0.423161317259943)
The number of points assigned to centroid_4 are 878769
The coordinates of Centroid_5 are (3.9983991469057094,0.19876659196067087, 237.17681264459242, 16.9528050896474,37.01825477154424,2.4554655870445345,11.141447368421053)
The number of points assigned to centroid_5 are 55328
The loss for the iteration of training is 24.61755408467621
```

The coordinates of Centroid\_0 are (2.5039500459551376,0.162286018349805,

237.07332419604916, 10.590452080343242, 0.4665226201417891, 0.7234897958086761,

18.21791874271033)

The number of points assigned to centroid\_0 is 186051

The coordinates of Centroid\_1 are (1.5182378319445107,0.11981336690635107,

240.91914146528174, 6.284366482359599, 0.10426455191271015, 0.39088985800690496,

17.741682458098627)

The number of points assigned to centroid\_1 is 462276

The coordinates of Centroid\_2 are (0.7050397154572775,0.12816193341890234,

238.8309410998368, 3.0693345802296323, 0.11100959431540725, 0.5232306079008326,

0.3973776059600576)

The number of points assigned to centroid\_2 is 511136

The coordinates of Centroid\_3 are (3.702262252794489,0.19049127257093884,

237.74208039553102, 15.735472914875196, 0.8496345657781599, 35.73701633705933,

10.558147033533963)

The number of points assigned to centroid\_3 is 46520

The coordinates of Centroid\_4 are (0.40038845690625946, 0.10479865578467527,

243.42590367136643, 1.7377234383575002, 0.025035248848622217, 0.3552703215481827,

0.423161317259943)

The number of points assigned to centroid\_4 is 787969

The coordinates of Centroid\_5 are (3.9983991469057094, 0.19876659196067087,

237.17681264459242, 16.9528050896474, 37.01825477154424, 2.4554655870445345,

11.141447368421053)

The number of points assigned to centroid\_5 is 55328

The loss for the iteration of training is 24.61755408467621

**K= 7:**

```
The coordinates of Centroid_0 are (4.407794364663061, 0.20088164645856674, 236.64681887235878, 18.704497377246838, 36.769140367472126, 2.6644595408031644, 17.634677673632012)
The number of points assigned to centroid_0 are 34887
The coordinates of Centroid_1 are (1.7976544528334562, 0.15933804457190676, 239.40171402992922, 7.640311195265599, 0.35316067594653905, 0.9659412309959358, 0.3792652686119012)
The number of points assigned to centroid_1 are 126223
The coordinates of Centroid_2 are (3.301619310344814, 0.19687847800237837, 238.06397384066517, 13.993217598097491, 36.97269916765755, 2.174601664684899, 0.39776456599286564)
The number of points assigned to centroid_2 are 21025
The coordinates of Centroid_3 are (0.36657432275969665, 0.11389735350770293, 239.5054205792203, 1.6399445678054538, 0.02636619354236488, 0.3958985921156321, 0.4267973727150825)
The number of points assigned to centroid_3 are 557877
The coordinates of Centroid_4 are (3.7122568949889874, 0.1905539298200196, 237.7271498554128, 15.775605334714365, 0.803983771418706, 35.763541801545166, 10.706353316932107)
The number of points assigned to centroid_4 are 46338
The coordinates of Centroid_5 are (0.40031110708475425, 0.10501105805233836, 243.9773858939434, 1.7338299893339284, 0.022965477220930872, 0.34721992589062545, 0.4190259447648502)
The number of points assigned to centroid_5 are 616926
The coordinates of Centroid_6 are (1.7992115725938847, 0.13172833192127206, 239.8166281594064, 7.51110184519641, 0.1984078638969456, 0.4769864587949858, 17.89001459483862)
The number of points assigned to centroid_6 are 646884
The loss for the iteration of training is 23.802470709466486
```

The coordinates of Centroid\_0 are (4.407794364663061, 0.20088164645856674,

236.64681887235878, 18.704497377246838, 36.769140367472126, 2.6644595408031644,

17.634677673632012)

The number of points assigned to centroid\_0 is 34887

The coordinates of Centroid\_1 are (1.7976544528334562, 0.15933804457190676,  
239.40171402992922, 7.640311195265599, 0.35316067594653905, 0.9659412309959358,  
0.3792652686119012)

The number of points assigned to centroid\_1 is 126223

The coordinates of Centroid\_2 are (3.301619310344814, 0.19687847800237837,  
238.06397384066517, 13.993217598097491, 36.97269916765755, 2.174601664684899,  
0.39776456599286564)

The number of points assigned to centroid\_2 is 21025

The coordinates of Centroid\_3 are (0.36657432275969665, 0.11389735350770293,  
239.5054205792203, 1.6399445678054538, 0.02636619354236488, 0.3958985921156321,  
0.4267973727150825)

The number of points assigned to centroid\_3 is 557077

The coordinates of Centroid\_4 are (3.7122568949889874, 0.1905539298200196,  
237.7271498554128, 15.775605334714365, 0.803983771418706, 35.763541801545166,  
10.706353316932107)

The number of points assigned to centroid\_4 is 46338

The coordinates of Centroid\_5 are (0.40031110700475425, 0.10501105805233836,  
243.9773858939434, 1.7338299893339284, 0.022965477220930872, 0.34721992589062545,  
0.4190259447648502)

The number of points assigned to centroid\_5 is 616926

The coordinates of Centroid\_6 are (1.7992115725938047, 0.13172833192127206,  
239.8166281594064, 7.511101044519641, 0.1984078638969456, 0.4769064507949858,  
17.89001459483862)

The number of points assigned to centroid\_6 is 646804

The loss for the iteration of training is 23.002470709466486

## K = 8:

```
The coordinates of Centroid_0 are (0.3664143366060461, 0.11376451856168097, 239.46724734829178, 1.639159626117929, 0.026379457365048816, 0.3960241828430361, 0.4151710638515432)
The number of points assigned to centroid_0 are 547661
The coordinates of Centroid_1 are (1.8009749560597559, 0.15926245635800984, 239.4059275960499, 7.656148052712463, 0.4056100334820541, 0.9762285368899069, 0.3469886033768361)
The number of points assigned to centroid_1 are 125739
The coordinates of Centroid_2 are (1.5977820195434815, 0.11529535285330214, 242.26100698184405, 6.573060039624134, 0.11014150860105311, 0.38327041315426097, 18.471929595321424)
The number of points assigned to centroid_2 are 283163
The coordinates of Centroid_3 are (2.933624466973095, 0.1783914284292057, 237.95767202043731, 12.396580331513505, 0.6506688579535084, 0.8869236257445785, 18.51729744976688)
The number of points assigned to centroid_3 are 128538
The coordinates of Centroid_4 are (3.7199294825668785, 0.19006968884237307, 237.72193083448028, 15.80775386493959, 0.8573733673491638, 35.96580972939971, 10.64130742897015)
The number of points assigned to centroid_4 are 45861
The coordinates of Centroid_5 are (0.3997286920674213, 0.10512593894556367, 243.94430875551095, 1.7318465729781807, 0.02294534501905454, 0.34774661052833417, 0.4167616064937244)
The number of points assigned to centroid_5 are 625835
The coordinates of Centroid_6 are (1.477286082243152, 0.1287501080001577, 237.90276761624912, 6.2898080449931405, 0.10841178628194156, 0.42055671027427965, 16.862326282756655)
The number of points assigned to centroid_6 are 245370
The coordinates of Centroid_7 are (4.002860958394557, 0.19860457605283705, 237.17127810135548, 16.96837043891662, 37.08489829985666, 2.462322863934099, 11.162611362110573)
The number of points assigned to centroid_7 are 55113
The loss for the iteration of training is 21.564362462298174
```

The coordinates of Centroid\_0 are (0.3664143366060461, 0.11376451856168097,  
239.46724734829178, 1.639159626117929, 0.026379457365048816, 0.3960241828430361,  
0.4151710638515432)

The number of points assigned to centroid\_0 is 547661

The coordinates of Centroid\_1 are (1.8009749560597559, 0.15926245635800984,  
239.4059275960499, 7.656148052712463, 0.4056100334820541, 0.9762285368899069,  
0.3469886033768361)

The number of points assigned to centroid\_1 is 125739

The coordinates of Centroid\_2 are (1.5977820195434815, 0.11529535285330214,  
242.26100698184405, 6.573060039624134, 0.11014150860105311, 0.38327041315426097,  
18.471929595321424)

The number of points assigned to centroid\_2 is 283163

The coordinates of Centroid\_3 are (2.933624466973095, 0.1783914284292057,  
237.95767202043731, 12.396580331513505, 0.6500688579535084, 0.8869236257445785,  
18.51729744976688)

The number of points assigned to centroid\_3 is 120538

The coordinates of Centroid\_4 are (3.7199294825668785, 0.19006968884237307,  
237.72193083448028, 15.80775386493959, 0.8573733673491638, 35.96580972939971,  
10.64130742897015)

The number of points assigned to centroid\_4 is 45861

The coordinates of Centroid\_5 are (0.3997286920674213, 0.10512593894556367,  
243.94430875551095, 1.7318465729781807, 0.02294534501905454, 0.34774661052833417,  
0.4167616064937244)

The number of points assigned to centroid\_5 is 625835

The coordinates of Centroid\_6 are (1.477286082243152, 0.1287501080001577,  
237.90276761624912, 6.2098080449931405, 0.10841178628194156, 0.42055671027427965,  
16.862326282756655)

The number of points assigned to centroid\_6 is 245370

The coordinates of Centroid\_7 are (4.002860958394557, 0.19860457605283705,  
237.17127810135548, 16.96837043891662, 37.08489829985666, 2.462322863934099,  
11.162611362110573)

The number of points assigned to centroid\_7 is 55113

The loss for the iteration of training is 21.564362462298174

## K = 9:

```
The coordinates of Centroid_0 are (0.36982255504206657, 0.11451616093119778, 241.35644170205137, 1.640933269856737, 0.024218052789568834, 0.3974969117046013, 0.4895105109196308)
The number of points assigned to centroid_0 are 653273
The coordinates of Centroid_1 are (3.720391056821891, 0.19007708583269872, 237.72050888864874, 15.80973279528835, 0.8576944050605301, 35.97114189115498, 10.6448903915367)
The number of points assigned to centroid_1 are 45845
The coordinates of Centroid_2 are (0.4150691693403972, 0.0995938997328716, 245.0964367146704, 1.7780396036810306, 0.021910644372517704, 0.32154174499300364, 0.36140549250187276)
The number of points assigned to centroid_2 are 353755
The coordinates of Centroid_3 are (4.003010034658571, 0.1986126041118512, 237.17104012048858, 16.968934293854208, 37.08602950516249, 2.4625015877624343, 11.163421582681595)
The number of points assigned to centroid_3 are 55109
The coordinates of Centroid_4 are (1.8297676744069316, 0.16068852978982506, 239.627681482916, 7.773462097056599, 0.4184180927666395, 1.0016192845099579, 0.35247817304642504)
The number of points assigned to centroid_4 are 119866
The coordinates of Centroid_5 are (2.9301774794190485, 0.17875954321384876, 237.9761656221314, 12.38112569875983, 0.6479807112718505, 0.8853988621632111, 18.566903647188024)
The number of points assigned to centroid_5 are 121107
The coordinates of Centroid_6 are (0.4048405360463531, 0.1093690736223666, 236.85912437643643, 1.8134370817568437, 0.03603770633325029, 0.37249199001141386, 0.2523508519846811)
The number of points assigned to centroid_6 are 172597
The coordinates of Centroid_7 are (1.4796027557264164, 0.1284317441321907, 237.8793794697525, 6.219561395240051, 0.18882332449457174, 0.4288999143446133, 16.87785295961902)
The number of points assigned to centroid_7 are 244001
The coordinates of Centroid_8 are (1.5943394376768232, 0.11526000133903071, 242.26133547343522, 6.558964293643085, 0.1095575202528657, 0.38263909199505264, 18.435428684189198)
The number of points assigned to centroid_8 are 283787
The loss for the iteration of training is 20.51944196622108
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The coordinates of Centroid\_0 are (0.36982255504206657, 0.11451616093119778,  
241.35644170205137, 1.640933269856737, 0.024218052789568834, 0.3974969117046013,  
0.4895105109196308)

The number of points assigned to centroid\_0 is 653273

The coordinates of Centroid\_1 are (3.720391056821891, 0.19007708583269872,  
237.72050888864874, 15.80973279528835, 0.8576944050605301, 35.97114189115498,  
10.6448903915367)

The number of points assigned to centroid\_1 is 45845

The coordinates of Centroid\_2 are (0.4150691693403972, 0.0995938997328716,  
245.0964367146704, 1.7780396036810306, 0.021910644372517704, 0.32154174499300364,  
0.36140549250187276)

The number of points assigned to centroid\_2 is 353755

The coordinates of Centroid\_3 are (4.003010034658571, 0.1986126041118512,  
237.17104012048858, 16.968934293854208, 37.08602950516249, 2.4625015877624343,  
11.163421582681595)

The number of points assigned to centroid\_3 is 55109

The coordinates of Centroid\_4 are (1.8297676744069316, 0.16068852978982506,  
239.6276814182916, 7.773462097056599, 0.41841810927666395, 1.0016192845099579,  
0.35247817304642504)

The number of points assigned to centroid\_4 is 119806

The coordinates of Centroid\_5 are (2.9301774794190485, 0.17875954321384876,  
237.9761656221314, 12.381112569875983, 0.6479807112718505, 0.8853988621632111,  
18.566903647188024)

The number of points assigned to centroid\_5 is 121107

The coordinates of Centroid\_6 are (0.4048405360463531, 0.1093690736223666,  
236.85912437643643, 1.8134370817568437, 0.03603770633325029, 0.37249199001141386,  
0.2523508519846811)

The number of points assigned to centroid\_6 is 172597

The coordinates of Centroid\_7 are (1.4796027557264164, 0.1284317441321907,  
237.8793794697525, 6.219561395240051, 0.10882332449457174, 0.4208999143446133,  
16.87785295961902)

The number of points assigned to centroid\_7 is 244001

The coordinates of Centroid\_8 are (1.5943394376768232, 0.11526000133903071,  
242.26133547343522, 6.558964293643085, 0.1095575202528657, 0.38263909199505264,  
18.435428684189198)

The number of points assigned to centroid\_8 is 283787

The loss for the iteration of training is 20.51944196622108

**K = 10:**

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The coordinates of Centroid_0 are (2.925139346648828, 0.17845132309022857, 237.97933758141517, 12.358216802122694, 0.64786916338771, 0.6207917744632355, 18.634800475829998)
The number of points assigned to centroid_0 are 120211
The coordinates of Centroid_1 are (3.9377495297163234, 0.19779933322158288, 237.24381497830214, 16.688599579073117, 37.08800357601833, 1.55083719804064, 11.060680560987874)
The number of points assigned to centroid_1 are 53691
The coordinates of Centroid_2 are (1.5912108926040294, 0.11519132568519318, 242.2658014680471, 6.54597556074238, 0.10914815154314242, 0.38275008637648866, 18.400448452626904)
The number of points assigned to centroid_2 are 283642
The coordinates of Centroid_3 are (0.40342340936852383, 0.10968047995686658, 236.8838614503082, 1.807706382026779, 0.03564689215309523, 0.38020292631446123, 0.25424292654388614)
The number of points assigned to centroid_3 are 174349
The coordinates of Centroid_4 are (0.4146920325685508, 0.09951408272085298, 245.110695287137, 1.776365310255568, 0.02167624703967899, 0.3208603241462448, 0.360641908740891)
The number of points assigned to centroid_4 are 350891
The coordinates of Centroid_5 are (4.744340680423435, 0.1883305358295672, 236.58148482892284, 20.104159365489128, 3.9121553075717053, 42.80563497187126, 16.196762888499492)
The number of points assigned to centroid_5 are 21686
The coordinates of Centroid_6 are (1.8258077815305517, 0.15862658904597626, 239.63648551400905, 7.74794378723309, 0.4181842869023575, 0.5268589079923285, 0.35145708515080026)
The number of points assigned to centroid_6 are 117838
The coordinates of Centroid_7 are (2.8811776769868174, 0.19463564057056257, 238.6626970354305, 12.390335239597693, 0.28889765332281603, 28.295306645632024, 6.279563531190429)
The number of points assigned to centroid_7 are 30426
The coordinates of Centroid_8 are (1.4805875155716217, 0.12828516924240202, 237.86773404705377, 6.223813576394303, 0.10902804330040168, 0.4241441263654715, 16.887025091374042)
The number of points assigned to centroid_8 are 243231
The coordinates of Centroid_9 are (0.3689626841569481, 0.11455129608229726, 241.3708643304135, 1.6373449254940757, 0.024117603283255396, 0.399891323481016, 0.48983874547500056)
The number of points assigned to centroid_9 are 653315
The loss for the iteration of training is 18.456484546834897

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The coordinates of Centroid\_0 are (2.925139346648828, 0.17845132309022857, 237.97933758141517, 12.358216802122694, 0.64786916338771, 0.6207917744632355, 18.634800475829998)

The number of points assigned to centroid\_0 is 120211

The coordinates of Centroid\_1 are (3.9377495297163234, 0.19779933322158288, 237.24381497830214, 16.688599579073117, 37.08800357601833, 1.55083719804064, 11.060680560987874)

The number of points assigned to centroid\_1 is 53691

The coordinates of Centroid\_2 are (1.5912108926040294, 0.11519132568519318, 242.2658014680471, 6.54597556074238, 0.10914815154314242, 0.38275008637648866, 18.400448452626904)

The number of points assigned to centroid\_2 is 283642

The coordinates of Centroid\_3 are (0.40342340936852383, 0.10968047995686658, 236.8838614503082, 1.807706382026779, 0.03564689215309523, 0.38020292631446123, 0.25424292654388614)

The number of points assigned to centroid\_3 is 174349

The coordinates of Centroid\_4 are (0.4146920325685508, 0.09951408272085298, 245.110695287137, 1.7763653100255568, 0.02167624703967899, 0.3208603241462448, 0.360641908740891)

The number of points assigned to centroid\_4 is 350891

The coordinates of Centroid\_5 are (4.744340680623435, 0.1883305358295672, 236.58148482892284, 20.104159365489128, 3.9121553075717053, 42.80563497187126, 16.196762888499492)

The number of points assigned to centroid\_5 is 21686

The coordinates of Centroid\_6 are (1.8250877815305517, 0.15862658904597626, 239.63648551400905, 7.74794378723309, 0.4181842869023575, 0.5268589079923285, 0.35145708515080026)

The number of points assigned to centroid\_6 is 117838

The coordinates of Centroid\_7 are (2.8811776769868174, 0.19463564057056257, 238.6626970354305, 12.300335239597693, 0.28889765332281603, 28.295306645632024, 6.279563531190429)

The number of points assigned to centroid\_7 is 30426

The coordinates of Centroid\_8 are (1.4805875155716217, 0.12828516924240202, 237.86773404705377, 6.223813576394303, 0.10902804330040168, 0.4241441263654715, 16.887025091374042)

The number of points assigned to centroid\_8 is 243231

The coordinates of Centroid\_9 are (0.3689626841569481, 0.11455129608229726,  
 241.3708643304135, 1.6373449254940757, 0.024117003283255396, 0.399891323481016,  
 0.48983874547500056)

The number of points assigned to centroid\_9 is 653315

The loss for the iteration of training is 18.456484546834897

## K = 11:

```
The coordinates of Centroid_0 are (2.655865596193859, 0.19005352363960717, 238.77512934879556, 11.341976409951387, 0.2438299137674695, 30.2929428089999, 0.49073248891981364)
The number of points assigned to centroid_0 are 20178
The coordinates of Centroid_1 are (2.49850271397328, 0.15636789919203764, 236.8415981279785, 10.57360590161692, 0.47364782938796784, 0.7452887916869695, 17.819489614377826)
The number of points assigned to centroid_1 are 176494
The coordinates of Centroid_2 are (3.8789824358678847, 0.19598332177798378, 237.30860315075807, 16.434219243509986, 37.03085278483938, 0.6000115553501271, 11.114667591894676)
The number of points assigned to centroid_2 are 51924
The coordinates of Centroid_3 are (0.3666193239469444, 0.11404984103279393, 241.361483452819, 1.6256068852422427, 0.024070638409250122, 0.39993225610272437, 0.44798269451351413)
The number of points assigned to centroid_3 are 649505
The coordinates of Centroid_4 are (1.5763506553641293, 0.1106193248763357, 240.94209856366314, 6.512475988316796, 0.11203770349756789, 0.3924437129509497, 18.414478275945224)
The number of points assigned to centroid_4 are 436246
The coordinates of Centroid_5 are (6.072657534246563, 0.23751761252446202, 234.90223336594855, 25.96394324853237, 36.096624266144815, 35.36619373776908, 12.235812133972407)
The number of points assigned to centroid_5 are 4088
The coordinates of Centroid_6 are (4.28616502692973, 0.1902899820466784, 237.2870093357276, 17.837967684021464, 0.3754039497387002, 37.79296229802514, 16.8220107719282)
The number of points assigned to centroid_6 are 27850
The coordinates of Centroid_7 are (1.8261863902797228, 0.15814212963753893, 239.63210286772918, 7.750682787589038, 0.41675923235982704, 0.5286241605003674, 0.29709315241724626)
The number of points assigned to centroid_7 are 117034
The coordinates of Centroid_8 are (0.40227804076608761, 0.10943609635651257, 236.86186362227164, 1.804161369164676, 0.035796599148916405, 0.3797191308033045, 0.23535422145589865)
The number of points assigned to centroid_8 are 172251
The coordinates of Centroid_9 are (0.41393831053438435, 0.0994350079756236, 245.10367901915194, 1.772746426612045, 0.021700497871747555, 0.3212594932569797, 0.34780507084223067)
The number of points assigned to centroid_9 are 351697
The coordinates of Centroid_10 are (1.0616053126413192, 0.2614783995430001, 240.7835405707773, 4.619208340275742, 0.06493228286482755, 0.44640944469568944, 11.014757337014734)
The number of points assigned to centroid_10 are 42013
The loss for the iteration of training is 16.997985880361753
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The coordinates of Centroid\_0 are (2.655865596193859, 0.19005352363960717,  
 238.77512934879556, 11.341976409951387, 0.2438299137674695, 30.2929428089999,  
 0.49073248091981364)

The number of points assigned to centroid\_0 is 20178

The coordinates of Centroid\_1 are (2.49850271397328, 0.15636789919203764,  
 236.8415981279785, 10.57360590161692, 0.47364782938796784, 0.7452887916869695,  
 17.819489614377826)

The number of points assigned to centroid\_1 is 176494

The coordinates of Centroid\_2 are (3.8789824358678047, 0.19598332177798378,  
237.30860315075807, 16.434219243509986, 37.03085278483938, 0.6000115553501271,  
11.114667591094676)

The number of points assigned to centroid\_2 is 51924

The coordinates of Centroid\_3 are (0.36661932394669444, 0.11404984103279393,  
241.361483452819, 1.6256068852422427, 0.024070638409250122, 0.39993225610272437,  
0.44798269451351413)

The number of points assigned to centroid\_3 is 649505

The coordinates of Centroid\_4 are (1.5763506553641293, 0.1106193248763357,  
240.94209856366314, 6.512475988316796, 0.11203770349756789, 0.3924437129509497,  
18.414470275945224)

The number of points assigned to centroid\_4 is 436246

The coordinates of Centroid\_5 are (6.072657534246563, 0.23751761252446202,  
234.90223336594855, 25.96394324853237, 36.096624266144815, 35.36619373776908,  
12.235812133072407)

The number of points assigned to centroid\_5 is 4088

The coordinates of Centroid\_6 are (4.206165026929973, 0.1902099820466784,  
237.2870093357276, 17.837967684021464, 0.3754039497307002, 37.79296229802514,  
16.82201077199282)

The number of points assigned to centroid\_6 is 27850

The coordinates of Centroid\_7 are (1.8261863902797228, 0.15814212963753893, 239.63210280772918, 7.750682707589038, 0.41675923235982704, 0.5286241605003674, 0.29709315241724626)

The number of points assigned to centroid\_7 is 117034

The coordinates of Centroid\_8 are (0.4027804076608761, 0.10943609035651257, 236.86106362227164, 1.804161369164676, 0.035796599148916405, 0.3797191308033045, 0.23535422145589865)

The number of points assigned to centroid\_8 is 172251

The coordinates of Centroid\_9 are (0.41393831053438435, 0.0994350079756236, 245.10367901915194, 1.772746426612045, 0.021700497871747555, 0.3212594932569797, 0.34780507084223067)

The number of points assigned to centroid\_9 is 351697

The coordinates of Centroid\_10 are (1.0616053126413192, 0.2614783995430001, 240.7835405707773, 4.619208340275742, 0.06493228286482755, 0.44640944469568944, 11.014757337014734)

The number of points assigned to centroid\_10 is 42013

The loss for the iteration of training is 16.99798580361753

**K = 12:**

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The coordinates of Centroid_0 are (4.003887161794066,0.19853993099691322, 237.17208135100793, 16.971919375340686,37.09751225712729,2.4627564917377884,11.171218449246414)
The number of points assigned to centroid_0 are 55070
The coordinates of Centroid_1 are (1.4826570051103287,0.12801080728251654, 237.84725401657778, 6.232513560743308,0.10930393003358685,0.42070734820849465,16.897475408887917)
The number of points assigned to centroid_1 are 242059
The coordinates of Centroid_2 are (0.42362069914665207,0.10458340765207948, 235.45581954307482, 1.8978210845030818,0.037676851087255714,0.3424057252958987,0.14413432424993)
The number of points assigned to centroid_2 are 90825
The coordinates of Centroid_3 are (1.5897956428912308,0.11520169536758462, 242.25972873416384, 6.540334157373119,0.10894176475545692,0.38191420625333594,18.3862755288367)
The number of points assigned to centroid_3 are 284776
The coordinates of Centroid_4 are (1.3947579062869078,0.1526819166643409, 241.2535862601223, 5.901959252750333,0.2187630764080676,0.4784872746208423,0.5066160813085242)
The number of points assigned to centroid_4 are 107541
The coordinates of Centroid_5 are (0.414991680826917,0.09249541560464283, 247.01938615123333, 1.7543631407531455,0.015390470121778533,0.29511823845935997,0.305180897762673)
The number of points assigned to centroid_5 are 112992
The coordinates of Centroid_6 are (2.282280671438515,0.1739271552543228, 237.87189839741424, 9.751508625240273,0.6713329532737907,1.9292455818078165,0.2734739536411817)
The number of points assigned to centroid_6 are 47361
The coordinates of Centroid_7 are (3.728704147468429,0.18991511959622745, 237.7178997147267, 15.8431160851436,0.8612025455343427,36.06436251920123,10.703247750713189)
The number of points assigned to centroid_7 are 45570
The coordinates of Centroid_8 are (0.372978556798465,0.10311223281782217, 243.95035917108308, 1.620185916595161,0.020557887043143767,0.3363861904255356,0.40020794657900427)
The number of points assigned to centroid_8 are 291421
The coordinates of Centroid_9 are (0.36078765827848136,0.11687058896935702, 239.44209678237598, 1.6190983149460563,0.026463259122337005,0.4165993971087739,0.440640952146971)
The number of points assigned to centroid_9 are 256431
The coordinates of Centroid_10 are (0.3405189926185835,0.11100189621164398, 241.72625625292255, 1.514115338470397,0.019279846269597577,0.3848013298899892,0.4858902535738251)
The number of points assigned to centroid_10 are 393416
The coordinates of Centroid_11 are (2.9253738035430086,0.1793621309123622, 238.00263516064518, 12.359677551757272,0.6452576794890739,0.8852468436520055,18.636630054671723)
The number of points assigned to centroid_11 are 121818

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The coordinates of Centroid\_0 are (4.003887161794066,0.19853993099691322,  
 237.17208135100793, 16.971919375340686,37.09751225712729,2.4627564917377884,  
 11.171218449246414)

The number of points assigned to centroid\_0 is 55070

The coordinates of Centroid\_1 are (1.4826570051103287,0.12801080728251654,  
 237.84725401657778, 6.232513560743308,0.10930393003358685,0.42070734820849465,  
 16.897475408887917)

The number of points assigned to centroid\_1 is 242059

The coordinates of Centroid\_2 are (0.42362069914665207,0.10458340765207948,  
 235.45581954307482, 1.8978210845030818,0.037676851087255714,0.3424057252958987,  
 0.1441343242499312)

The number of points assigned to centroid\_2 is 90825

The coordinates of Centroid\_3 are (1.5897956428912308,0.11520169536758462,  
 242.25972873416384, 6.540334157373119,0.10894176475545692,0.38191420625333594,  
 18.3862755288367)

The number of points assigned to centroid\_3 is 284776

The coordinates of Centroid\_4 are (1.3947579062869078, 0.1526819166643409,  
241.2535862601223, 5.901959252750333, 0.2187630764080676, 0.4784872746208423,  
0.5066160813085242)

The number of points assigned to centroid\_4 is 107541

The coordinates of Centroid\_5 are (0.4149991680826917, 0.09249541560464203,  
247.01938615123333, 1.7543631407531455, 0.015390470121778533, 0.29511823845935997,  
0.3051808977626735)

The number of points assigned to centroid\_5 is 112992

The coordinates of Centroid\_6 are (2.282200671438515, 0.1739271552543228,  
237.87189839741424, 9.751508625240273, 0.6713329532737907, 1.9292455818078165,  
0.27347395536411817)

The number of points assigned to centroid\_6 is 47361

The coordinates of Centroid\_7 are (3.728704147465429, 0.18991511959622745,  
237.7178997147267, 15.8431160851436, 0.8612025455343427, 36.06436251920123,  
10.703247750713189)

The number of points assigned to centroid\_7 is 45570

The coordinates of Centroid\_8 are (0.372978556795845, 0.10311223281782217,  
243.95035917108308, 1.620185916595161, 0.020557887043143767, 0.3363861904255356,  
0.40020794657900427)

The number of points assigned to centroid\_8 is 291421

The coordinates of Centroid\_9 are (0.36078765827848136, 0.11687058896935702, 239.44209678237598, 1.6190983149460563, 0.026463259122337005, 0.4165993971087739, 0.4406409521469713)

The number of points assigned to centroid\_9 is 256431

The coordinates of Centroid\_10 are (0.3405189926185835, 0.11100189621164398, 241.72625625292255, 1.514115338470397, 0.019279846269597577, 0.3848013298899892, 0.48589025357382515)

The number of points assigned to centroid\_10 is 393416

The coordinates of Centroid\_11 are (2.9253738035430086, 0.17936213039123622, 238.00263516064518, 12.359677551757272, 0.6452576794890739, 0.8852468436520055, 18.636630054671723)

The number of points assigned to centroid\_11 is 121818

The loss for the iteration of training is 19.47433628374531

## K = 13:

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The coordinates of Centroid_0 are (4.744412803837452, 0.18830976430976404, 236.58148563258246, 20.104450901711047, 3.9105668557723354, 42.80748120474148, 16.19796134864628)
The number of points assigned to centroid_0 are 21681
The coordinates of Centroid_1 are (0.3550479457110205, 0.10687657793244934, 242.97038551378304, 1.5505630730321862, 0.01942437387776968, 0.3577789430434773, 0.4280785146948328)
The number of points assigned to centroid_1 are 448529
The coordinates of Centroid_2 are (3.01598667838854, 0.17664035640102455, 237.93631202007168, 12.746239085688474, 0.7099730255552318, 0.6416534300779158, 18.16602911736233)
The number of points assigned to centroid_2 are 106397
The coordinates of Centroid_3 are (0.404907967172524, 0.09404066105823956, 246.32479410885688, 1.7202408863146, 0.01721601618167609, 0.29729232749505813, 0.385796981576794)
The number of points assigned to centroid_3 are 174024
The coordinates of Centroid_4 are (2.8821120485104426, 0.1946152122338589, 238.66163524914342, 12.304145794885294, 0.2896124439757448, 28.330015818613234, 6.273082988879093)
The number of points assigned to centroid_4 are 30344
The coordinates of Centroid_5 are (0.4133446158350732, 0.1058423894788515, 235.98881088363222, 1.8510589187745383, 0.03683687644540905, 0.3621769199631381, 0.16789299828747745)
The number of points assigned to centroid_5 are 116109
The coordinates of Centroid_6 are (1.0627536044759982, 0.262279367811971, 240.79964923606803, 4.623250364632012, 0.06431867632642325, 0.44399014896109795, 11.018554383951415)
The number of points assigned to centroid_6 are 41823
The coordinates of Centroid_7 are (2.2639769193193784, 0.16651970202719116, 237.86218920459004, 9.652405764064268, 0.6858462916225678, 0.5250549540014654, 0.232984612879587)
The number of points assigned to centroid_7 are 49132
The coordinates of Centroid_8 are (0.3413179171042605, 0.11427276298721774, 240.28361181050033, 1.5291227376602938, 0.022069306319105565, 0.40529248254987954, 0.4376379022793255)
The number of points assigned to centroid_8 are 404725
The coordinates of Centroid_9 are (1.6171372329724643, 0.11263326229012309, 242.16157184860296, 6.651063186252907, 0.1117769946612083, 0.3834645170820233, 18.725527021038637)
The number of points assigned to centroid_9 are 284334
The coordinates of Centroid_10 are (3.9393879377867123, 0.19771981649323045, 237.24364514564945, 16.694315765917253, 37.10978702771251, 1.552758196262728, 11.069840737010928)
The number of points assigned to centroid_10 are 53622
The coordinates of Centroid_11 are (1.3545538412267863, 0.15329644700651823, 241.339033570708042, 5.729989450284479, 0.19844768471421576, 0.5580140160586386, 0.37316792886477523)
The number of points assigned to centroid_11 are 186164
The coordinates of Centroid_12 are (1.5570512078259224, 0.11209218860596121, 237.54883464309054, 6.532408029183343, 0.11852755948383818, 0.425021325258912, 17.662366830613987)
The number of points assigned to centroid_12 are 220396
The loss for the iteration of training is 16.832525231491093
```

The coordinates of Centroid\_0 are (4.744412803837452, 0.18830976430976404,  
236.58148563258246, 20.104450901711047, 3.9105668557723354, 42.80748120474148,  
16.19796134864628)

The number of points assigned to centroid\_0 is 21681

The coordinates of Centroid\_1 are (0.3530470457110205, 0.10687657793244934,  
242.97038551378304, 1.5505630730321862, 0.01942437387776968, 0.3577789430434773,  
0.4280785146948328)

The number of points assigned to centroid\_1 is 440529

The coordinates of Centroid\_2 are (3.015906670300854, 0.17664035640102455,  
237.93631202007168, 12.746239085688474, 0.7099730255552318, 0.6416534300779158,  
18.16602911736233)

The number of points assigned to centroid\_2 is 106397

The coordinates of Centroid\_3 are (0.4049079667172524, 0.09404066105823956,  
246.32479410885688, 1.7202408863146, 0.01721601618167609, 0.29729232749505813,  
0.305796901576794)

The number of points assigned to centroid\_3 is 174024

The coordinates of Centroid\_4 are (2.8821120485104426, 0.1946152122330589,  
238.66163524914342, 12.304145794885294, 0.2896124439757448, 28.330015818613234,  
6.273002900079093)

The number of points assigned to centroid\_4 is 30344

The coordinates of Centroid\_5 are (0.4133446158350732, 0.1058423894788515,  
235.98881008363222, 1.8510589187745383, 0.03683607644540905, 0.3621769199631381,  
0.16709299020747745)

The number of points assigned to centroid\_5 is 116109

The coordinates of Centroid\_6 are (1.0627536044759982, 0.262279367811971,  
240.79964923606803, 4.623250364632012, 0.06431867632642325, 0.44399014896109795,  
11.018554383951415)

The number of points assigned to centroid\_6 is 41823

The coordinates of Centroid\_7 are (2.2639769193193784, 0.16651970202719116,  
237.86218920459004, 9.652405764064268, 0.6858462916225678, 0.5250549540014654,  
0.2329846128795897)

The number of points assigned to centroid\_7 is 49132

The coordinates of Centroid\_8 are (0.3413179171042605, 0.11427276298721774,  
240.28361181050033, 1.5291227376602938, 0.022069306319105565, 0.40529248254987954,  
0.4376379022793255)

The number of points assigned to centroid\_8 is 404725

The coordinates of Centroid\_9 are (1.6171372329724643, 0.11263326229012309,  
242.16157184860296, 6.651063186252907, 0.1117769946612083, 0.3834645170820233,  
18.725527021038637)

The number of points assigned to centroid\_9 is 284334

The coordinates of Centroid\_10 are (3.9393879377867123, 0.19771981649323045, 237.24364514564945, 16.694315765917253, 37.10978702771251, 1.552758196262728, 11.069840737010928)

The number of points assigned to centroid\_10 is 53622

The coordinates of Centroid\_11 are (1.3545538412267863, 0.15329644700651823, 241.33903357070042, 5.729989450284479, 0.19844768471421576, 0.5580140160506386, 0.37316792886477523)

The number of points assigned to centroid\_11 is 106164

The coordinates of Centroid\_12 are (1.5570512078259224, 0.11209218860596121, 237.54883464309034, 6.532408029183343, 0.11852755948383818, 0.425021325250912, 17.662366830613987)

The number of points assigned to centroid\_12 is 220396

The loss for the iteration of training is 16.832525231491093

**K = 14:**

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The coordinates of Centroid_0 are (0.4183641852919429,0.10445255046863858, 235.419286341922, 1.8761603280460615,0.036984048305695745,0.35745989545782264,0.1417064708002884)
The number of points assigned to centroid_0 are 88768
The coordinates of Centroid_1 are (0.33724059640635357,0.11045848349687734, 241.67147995412847, 1.5001182617553095,0.01876640754428444,0.3813865171403084,0.47801452784503634
The number of points assigned to centroid_1 are 392350
The coordinates of Centroid_2 are (1.5895703211438847,0.11520117125560983, 242.26660001127536, 6.539236358255136,0.10897187436134152,0.3823388466444443,18.384375506522243)
The number of points assigned to centroid_2 are 283798
The coordinates of Centroid_3 are (6.016572011936538,0.19581718234647394, 235.23215486100227, 25.63565258363436,14.572797235746819,57.63138055599183,12.099575938432542)
The number of points assigned to centroid_3 are 6367
The coordinates of Centroid_4 are (1.4818809302939273,0.12807112023648487, 237.85658391981286, 6.228979125695078,0.10915410209155339,0.4253196287729801,16.908307981545843)
The number of points assigned to centroid_4 are 242547
The coordinates of Centroid_5 are (0.4124584739982146,0.09247175333925892, 246.97969849506802, 1.744332194401136,0.015308369093153973,0.2880788126300521,0.30502767248896984
The number of points assigned to centroid_5 are 115819
The coordinates of Centroid_6 are (0.369373251202436414,0.103255374230031, 243.90069891147076, 1.6062185469583394,0.02832571091047169,0.33729136781706187,0.4033786178381571)
The number of points assigned to centroid_6 are 296275
The coordinates of Centroid_7 are (2.921750421977784,0.17840168957402686, 237.98814820357615, 12.343156476838798,0.6455553061105707,0.5917749673642811,18.653471026965804)
The number of points assigned to centroid_7 are 120267
The coordinates of Centroid_8 are (1.3553485832181877,0.15516036039446462, 241.39734246938113, 5.7402263822376955,0.19753553784709735,0.5649807877950446,0.5495542389884727)
The number of points assigned to centroid_8 are 195662
The coordinates of Centroid_9 are (0.36331942322508627,0.11712103487336607, 239.3869288141635, 1.6303536516047814,0.026923960672232322,0.41654136550717746,0.4373097807464858
The number of points assigned to centroid_9 are 248069
The coordinates of Centroid_10 are (2.2590444284053013,0.16653466458157812, 237.90196865712205, 9.6310083648983407,0.6820040899795501,0.5285095633345362,0.2660291110309154)
The number of points assigned to centroid_10 are 49878
The coordinates of Centroid_11 are (2.6652311311131183,0.18890170170170148, 238.76044894894864, 11.38153153153149,0.3013513513513,30.446046046046046,0.383933939393394)
The number of points assigned to centroid_11 are 19800
The coordinates of Centroid_12 are (3.8824445795493516,0.19478922369570933, 237.6386039442184, 16.457643348405863,0.4674164988410533,31.61272181479652,17.617623589314892)
The number of points assigned to centroid_12 are 26317
The coordinates of Centroid_13 are (3.9239022243958097,0.1973915724949701, 237.260090818054257,37.09792602899423,1.2586164751894402,11.132579959761578)
The number of points assigned to centroid_13 are 53183
The loss for the iteration of training is 15.175734083180993

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The coordinates of Centroid\_0 are (0.4183641852919429,0.10445255046863858,  
 235.419286341922,  
 1.8761603280460615,0.036984048305695745,0.35745989545782264,0.1417064708002884)

The number of points assigned to centroid\_0 is 88768

The coordinates of Centroid\_1 are (0.33724059640635357,0.11045848349687734,  
 241.67147995412847, 1.5001182617553095, 0.01876640754428444, 0.3813865171403084,  
 0.47801452784503634)

The number of points assigned to centroid\_1 is 392350

The coordinates of Centroid\_2 are (1.5895703211438847,0.11520117125560983,  
 242.26660001127536, 6.539236358255136, 0.10897187436134152, 0.3823388466444443,  
 18.384375506522243)

The number of points assigned to centroid\_2 is 283798

The coordinates of Centroid\_3 are (6.016572011936538, 0.19581718234647394, 235.23215486100227, 25.63565258363436, 14.572797235746819, 57.63138055599183, 12.099575938432542)

The number of points assigned to centroid\_3 is 6367

The coordinates of Centroid\_4 are (1.4818809302939273, 0.12807112023648487, 237.85658391981286, 6.228979125695078, 0.10915410209155339, 0.4253196287729801, 16.900307981545843)

The number of points assigned to centroid\_4 is 242547

The coordinates of Centroid\_5 are (0.4124584739982146, 0.09247175333925892, 246.97969849506802, 1.7443321044041136, 0.015308369093153973, 0.2880788126300521, 0.30502767248896984)

The number of points assigned to centroid\_5 is 115819

The coordinates of Centroid\_6 are (0.36937325120243414, 0.103255374230031, 243.90069891147076, 1.6062185469583394, 0.02032571091047169, 0.33729136781706187, 0.4033786178381571)

The number of points assigned to centroid\_6 is 296275

The coordinates of Centroid\_7 are (2.921750421977784, 0.17840168957402686, 237.98814820357615, 12.343156476838798, 0.6455553061105707, 0.5917749673642811, 18.653471026965004)

The number of points assigned to centroid\_7 is 120267

The coordinates of Centroid\_8 are (1.3553485832181877, 0.15516036039446462, 241.39734246938113, 5.7402263822376955, 0.19753553784709735, 0.5649807877950446, 0.5495542389884727)

The number of points assigned to centroid\_8 is 105662

The coordinates of Centroid\_9 are (0.36331942322500627, 0.11712103487336607, 239.3809288141635, 1.6303536516047814, 0.026923960672232322, 0.41654136550717746, 0.43730978074648585)

The number of points assigned to centroid\_9 is 248069

The coordinates of Centroid\_10 are (2.2590444284053013, 0.16653466458157812, 237.90190865712205, 9.631003648903407, 0.6820040899795501, 0.5285095633345362, 0.2660291110309154)

The number of points assigned to centroid\_10 is 49878

The coordinates of Centroid\_11 are (2.6652311311311183, 0.18890170170170148, 238.76044894894864, 11.38153153153149, 0.3013513513513513, 30.446046046046046, 0.38393393393393394)

The number of points assigned to centroid\_11 is 19980

The coordinates of Centroid\_12 are (3.8824445795493516, 0.19478922369570933, 237.6386039442184, 16.457643348405863, 0.4674164988410533, 31.61272181479652, 17.617623589314892)

The number of points assigned to centroid\_12 is 26317

The coordinates of Centroid\_13 are (3.9239022243950097, 0.1973915724949701,  
 237.26009081849466, 16.628509110054257, 37.09792602899423, 1.2586164751894402,  
 11.132579959761578)

The number of points assigned to centroid\_13 is 53183

The loss for the iteration of training is 15.175734083180993

**K = 15:**

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The coordinates of Centroid_0 are (1.3514460673566966, 0.1509491146955281, 242.58516786633723, 5.692300215415011, 0.19041927179109966, 0.5354515840907896, 0.3654573635265066)
The number of points assigned to centroid_0 are 76132
The coordinates of Centroid_1 are (1.5548168280793595, 0.11188659337823686, 237.54647266427276, 6.522901558223259, 0.11895393518305213, 0.42664553404410205, 17.600584218722645)
The number of points assigned to centroid_1 are 217042
The coordinates of Centroid_2 are (2.880905128798681, 0.1944851691412303, 238.66258398926268, 12.29920368681576, 0.29165702192387816, 28.342515128467973, 6.238558312489666)
The number of points assigned to centroid_2 are 30241
The coordinates of Centroid_3 are (3.9405135992239506, 0.1976921240159685, 237.242160194011, 16.698660597694566, 37.12054620751408, 1.5653285080028354, 11.070234675222922)
The number of points assigned to centroid_3 are 53686
The coordinates of Centroid_4 are (3.0215256073214265, 0.1693673775968036, 237.93723745329746, 12.76887786351703, 0.717805538534522, 0.6363977782609556, 17.583839822751082)
The number of points assigned to centroid_4 are 101182
The coordinates of Centroid_5 are (0.3446070763140852, 0.10151303760197839, 235.86935328474323, 1.5608109282231768, 0.030120191147366897, 0.3344306608099628, 0.1513346527806806)
The number of points assigned to centroid_5 are 103585
The coordinates of Centroid_6 are (4.741145725865873, 0.18823516949152516, 236.58860491893975, 20.09042804421505, 3.87076271186440866, 42.7880895357406, 16.210252394988945)
The number of points assigned to centroid_6 are 21712]
The coordinates of Centroid_7 are (1.5986063612531139, 0.10721982477461754, 242.2195022304934, 6.5701410715064394, 0.1123720000579349, 0.3819322740900598, 18.369658073142825)
The number of points assigned to centroid_7 are 276172
The coordinates of Centroid_8 are (0.34337375378962615, 0.11482350288081627, 240.269485413267, 1.5381611251914935, 0.02254361115252721, 0.40771581929327566, 0.43749316634362106)
The number of points assigned to centroid_8 are 402428
The coordinates of Centroid_9 are (1.3756911590387617, 0.1528081097307527, 238.31252405363423, 5.87519820194285, 0.16245631860096368, 0.584230052802537, 0.3383826721479466)
The number of points assigned to centroid_9 are 64959
The coordinates of Centroid_10 are (2.3420501711722417, 0.2687656711328965, 238.99102113091766, 9.852638413410414, 0.2568500531224177, 0.5451540558112147, 28.362708062802564)
The number of points assigned to centroid_10 are 16942
The coordinates of Centroid_11 are (0.34650692909404246, 0.10642778116154222, 242.94026185701725, 1.5236551854711102, 0.018386336625080695, 0.35644628155731817, 0.42876435149383)
The number of points assigned to centroid_11 are 438369
The coordinates of Centroid_12 are (1.0581988318150055, 0.26226642309448966, 240.80389851693624, 4.603538206379458, 0.06184650145422054, 0.4435737807369661, 11.019638006874505)
The number of points assigned to centroid_12 are 41693
The coordinates of Centroid_13 are (2.5594089681923826, 0.17170525989138846, 238.32485554693397, 10.908617532971128, 0.994010861132661, 0.5078665632273079, 0.220822342981474)
The number of points assigned to centroid_13 are 32225
The coordinates of Centroid_14 are (0.3861984747819225, 0.09321413137673507, 246.31268912126384, 1.6436258593794855, 0.015385059795482119, 0.2934080536137269, 0.306903922814720)
The number of points assigned to centroid_14 are 173090
The loss for the iteration of training is 15.800654644682561
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The coordinates of Centroid\_0 are (1.3514460673566966, 0.1509491146955281,  
 242.58516786633723, 5.692300215415011, 0.19041927179109966, 0.5354515840907896,  
 0.3654573635265066)

The number of points assigned to centroid\_0 is 76132

The coordinates of Centroid\_1 are (1.5548168280793595, 0.11188659337823686,  
 237.54647266427276, 6.522901558223259, 0.11895393518305213, 0.42664553404410205,  
 17.600584218722645)

The number of points assigned to centroid\_1 is 217042

The coordinates of Centroid\_2 are (2.880905128798681, 0.1944851691412303,  
238.66258390926268, 12.299203068681576, 0.29165702192387816, 28.342515128467973,  
6.238550312489666)

The number of points assigned to centroid\_2 is 30241

The coordinates of Centroid\_3 are (3.9405135992239506, 0.1976921240159685,  
237.2421600194011, 16.698660597694566, 37.12054620751408, 1.5653285080028354,  
11.070234675222922)

The number of points assigned to centroid\_3 is 53606

The coordinates of Centroid\_4 are (3.0215256073214265, 0.1693673775968036,  
237.93723745329746, 12.768877863651703, 0.717805538534522, 0.6363977782609556,  
17.583839022751082)

The number of points assigned to centroid\_4 is 101182

The coordinates of Centroid\_5 are (0.3446070763140852, 0.10151303760197039,  
235.86935328474323, 1.5608109282231768, 0.030120191147366897, 0.3344306608099628,  
0.1513346527006806)

The number of points assigned to centroid\_5 is 103585

The coordinates of Centroid\_6 are (4.741145725865873, 0.18823516949152516,  
236.58860491893975, 20.09042004421505, 3.8707627118644066, 42.7880895357406,  
16.210252394988945)

The number of points assigned to centroid\_6 is 21712

The coordinates of Centroid\_7 are (1.5986063612531138, 0.10721982677461754,  
242.2195022304934, 6.5701410715064394, 0.1123720000579349, 0.3819322740900598,  
18.369650073142825)

The number of points assigned to centroid\_7 is 276172

The coordinates of Centroid\_8 are (0.34337375378962615, 0.11482350280801627,  
240.269485413267, 1.5381611251914935, 0.02254361115252721, 0.40771581929327566,  
0.43749316634362106)

The number of points assigned to centroid\_8 is 402420

The coordinates of Centroid\_9 are (1.3756911590387617, 0.1528081097307527,  
238.31252405363423, 5.87519820194285, 0.16245631860096368, 0.584230052802537,  
0.3383826721470466)

The number of points assigned to centroid\_9 is 64959

The coordinates of Centroid\_10 are (2.3420501711722417, 0.26876567111320965,  
238.99102113091766, 9.852638413410414, 0.2560500531224177, 0.5451540550112147,  
28.362708062802504)

The number of points assigned to centroid\_10 is 16942

The coordinates of Centroid\_11 are (0.34650692909404246, 0.10642778116154222,  
242.94026185701725, 1.5236551854711102, 0.018386336625080695, 0.35644628155731817,  
0.4287643514938328)

The number of points assigned to centroid\_11 is 438369

The coordinates of Centroid\_12 are (1.0581988318150055, 0.26226642309448966, 240.80389851693624, 4.603538206379458, 0.061846501454222054, 0.4435737807369661, 11.019638006874505)

The number of points assigned to centroid\_12 is 41603

The coordinates of Centroid\_13 are (2.5594089681923826, 0.17170525989138846, 238.32485554693397, 10.908617532971128, 0.994010861132661, 0.5078665632273079, 0.220822342901474)

The number of points assigned to centroid\_13 is 32225

The coordinates of Centroid\_14 are (0.3861984747819225, 0.09321413137673507, 246.31268912126384, 1.6436258593794855, 0.015385059795482119, 0.29340805361372696, 0.3069039228147207)

The number of points assigned to centroid\_14 is 173090

The loss for the iteration of training is 15.800654644682561

**K = 16:**

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The coordinates of Centroid_0 are (3.013679984982871,0.1765286404805463, 237.93850016424548, 12.736075836501007,0.6889483316908348,0.6476418414754329,18.165573231967713)
The number of points assigned to centroid_0 are 106545
The coordinates of Centroid_1 are (1.6168416369418668,0.11260730614468152, 242.1595793431877, 6.64987787949616,0.11183075328143945,0.3833634973906626,18.72436260125459)
The number of points assigned to centroid_1 are 284555
The coordinates of Centroid_2 are (3.3030657963695114,0.19671856686835995, 238.06658583067255, 13.99738910858068,37.006765448568295,2.182571823336033,0.39739863738148556)
The number of points assigned to centroid_2 are 20989
The coordinates of Centroid_3 are (1.3799083696216715,0.15306098437936924, 241.47308757060933, 5.830647996484464,0.22714833606328153,0.5528844233150892,0.36999121089848586)
The number of points assigned to centroid_3 are 100124
The coordinates of Centroid_4 are (0.3855525796196441,0.09822297173442514, 244.79266603470026, 1.65802481420789,0.020697789739759818,0.3140846029360162,0.33956394450583693)
The number of points assigned to centroid_4 are 190939
The coordinates of Centroid_5 are (4.469847847499862,0.2001163479923544, 236.64843878556027, 18.70749174343847,36.93052899936265,2.60241036635958,17.632220870270583)
The number of points assigned to centroid_5 are 34818
The coordinates of Centroid_6 are (0.40579717225753353,0.10352337800584165, 235.05585255342982, 1.8263231159755506,0.035919971613396294,0.3495782951660889,0.1172271565630373)
The number of points assigned to centroid_6 are 73274
The coordinates of Centroid_7 are (0.35140851418846673,0.10886967252627441, 242.75977989520877, 1.5478715814504274,0.019086030144294115,0.3684127647266767,0.4428993797602596)
The number of points assigned to centroid_7 are 311170
The coordinates of Centroid_8 are (1.6634133314172027,0.26249177265215357, 240.80158343512915, 4.625537112883634,0.0646451581998036,0.444085171612656,11.827328686738041)
The number of points assigned to centroid_8 are 41751
The coordinates of Centroid_9 are (0.4137158619212405,0.09138068875385898, 247.62312752738296, 1.7444364183796774,0.012693821894450871,0.2852360675932621,0.2976486971425511)
The number of points assigned to centroid_9 are 74682
The coordinates of Centroid_10 are (0.3975286969614563,0.11868646204471768, 238.72713775878393, 1.777143973200931,0.03413785348184799,0.42672908701364883,0.3669937619109622)
The number of points assigned to centroid_10 are 168962
The coordinates of Centroid_11 are (2.884673113863708,0.19484758561303378, 238.6526843001411, 12.316938051599652,0.35288467987531296,28.32980062264026,6.184175664839213)
The number of points assigned to centroid_11 are 30194
The coordinates of Centroid_12 are (4.616622763908,0.18512649891881217, 236.7506919598987, 19.548270100255504,1.4761155887556516,43.23019461372125,16.37251818360527)
The number of points assigned to centroid_12 are 20348
The coordinates of Centroid_13 are (2.245532143217348,0.1651837014624297, 237.8302991427112, 9.56332425617752,0.4998487140695915,0.5254261220373172,0.2324155320221886)
The number of points assigned to centroid_13 are 49575
The coordinates of Centroid_14 are (1.5565822815887185,0.1120716519967967, 237.5453565323278, 6.530509383865071,0.11859405688513858,0.4248245071651997,17.661326107514366)
The number of points assigned to centroid_14 are 219952
The coordinates of Centroid_15 are (0.33085548302467111,0.11118605417437413, 240.90138112292067, 1.4769563136067219,0.01917613194820051,0.3893261465579947,0.45279793108446997)
The number of points assigned to centroid_15 are 321702
The loss for the iteration of training is 14.484543662011378

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The coordinates of Centroid\_0 are (3.013679984982871,0.1765286404805463,  
 237.93850016424548, 12.736075836501007,0.6889483316908348, 0.6476418414754329,  
 18.165573231967713)

The number of points assigned to centroid\_0 is 106545

The coordinates of Centroid\_1 are (1.6168416369418668,0.11260730614468152,  
 242.1595793431877, 6.64987787949616, 0.11183075328143945, 0.3833634973906626,  
 18.72436260125459)

The number of points assigned to centroid\_1 is 284555

The coordinates of Centroid\_2 are (3.3030657963695114,0.19671856686835995,  
 238.06658583067255, 13.99738910858068,37.006765448568295, 2.182571823336033,  
 0.39739863738148556)

The number of points assigned to centroid\_2 is 20989

The coordinates of Centroid\_3 are (1.3790083696216715, 0.15306098437936924,  
241.47300757060933, 5.830647996484464, 0.22714833606328153, 0.5528844233150892,  
0.36999121089848586)

The number of points assigned to centroid\_3 is 100124

The coordinates of Centroid\_4 are (0.3855525796196441, 0.09822297173442514,  
244.79266603470026, 1.65802481420789, 0.020697709739759818, 0.3140846029360162,  
0.33956394450583693)

The number of points assigned to centroid\_4 is 190939

The coordinates of Centroid\_5 are (4.409847847499862, 0.20011663479923544,  
236.64843878556027, 18.70749174343847, 36.93052899936265, 2.602410336635958,  
17.632220870270583)

The number of points assigned to centroid\_5 is 34518

The coordinates of Centroid\_6 are (0.40579717225753353, 0.10352337800584165,  
235.05585255342902, 1.8263231159755506, 0.035919971613396294, 0.3495782951660889,  
0.11727215656303737)

The number of points assigned to centroid\_6 is 73274

The coordinates of Centroid\_7 are (0.35140051418840673, 0.10886967252627441,  
242.75977989520877, 1.5478715814504274, 0.019086030144294115, 0.3684127647266767,  
0.44289937976025967)

The number of points assigned to centroid\_7 is 311170

The coordinates of Centroid\_8 are (1.0634133314172027, 0.26249177265215357,  
240.80158343512915, 4.625537112883634, 0.0646451581998036, 0.444085171612656,  
11.027328686738041)

The number of points assigned to centroid\_8 is 41751

The coordinates of Centroid\_9 are (0.4137158619212405, 0.09138068075305898,  
247.62312752738296, 1.7444364103796774, 0.012693821804450871, 0.2852360675932621,  
0.2976486971425511)

The number of points assigned to centroid\_9 is 74682

The coordinates of Centroid\_10 are (0.3975206969614563, 0.11868646204471768,  
238.72713775878393, 1.777143973200931, 0.03413785348184799, 0.42672908701364803,  
0.3669937619109622)

The number of points assigned to centroid\_10 is 168962

The coordinates of Centroid\_11 are (2.884673113863708, 0.19484758561303378,  
238.6526843081411, 12.31693051599652, 0.35288467907531296, 28.32980062264026,  
6.184175664039213)

The number of points assigned to centroid\_11 is 30194

The coordinates of Centroid\_12 are (4.616622763908, 0.18512649891881217,  
236.7506919598987, 19.548270100255504, 1.4761155887556516, 43.23019461372125,  
16.37251818360527)

The number of points assigned to centroid\_12 is 20348

The coordinates of Centroid\_13 are (2.245532143217348, 0.1651837014624297, 237.8302991427112, 9.56332425617752, 0.4998487140695915, 0.5254261220373172, 0.2324155320221886)

The number of points assigned to centroid\_13 is 49575

The coordinates of Centroid\_14 are (1.5565822815887185, 0.1120716519967967, 237.5453565323278, 6.530509383865071, 0.11859405688513858, 0.4248245071651997, 17.661326107514366)

The number of points assigned to centroid\_14 is 219952

The coordinates of Centroid\_15 are (0.3305548302467111, 0.11118605417437413, 240.90138112292067, 1.4769563136067219, 0.01917613194820051, 0.3893261465579947, 0.45279793100446997)

The number of points assigned to centroid\_15 is 321702

The loss for the iteration of training is 14.484543662011378

**K = 17:**

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The coordinates of Centroid_0 are (2.9919285097990946,0.24628374214224008, 238.192707999507, 13.39583384691235,20.05127573030938,0.7222975471465549,12.626895106619006)
The number of points assigned to centroid_0 are 8113
The coordinates of Centroid_1 are (1.5750814746838067,0.10276555081195024, 243.42005373126435, 6.436176834378545,0.10288074053385468,0.3549388873372435,18.534825572889652)
The number of points assigned to centroid_1 are 150378
The coordinates of Centroid_2 are (1.0549956600800043,0.2624435931628092, 240.84364626015457, 4.5891332282702,0.04805430961328646,0.44432052369984243,11.006425021214692)
The number of points assigned to centroid_2 are 41245
The coordinates of Centroid_3 are (1.579929731010766,0.1109134079867276, 234.75160875103677, 6.711257257969028,0.13135442587984358,0.4310048583955445,17.040585377414384)
The number of points assigned to centroid_3 are 67512
The coordinates of Centroid_4 are (1.8339734897257032,0.15720576770438138, 239.6392566363863, 7.770902195960859,0.247632063197813,0.523793985360261,0.2933327453920899)
The number of points assigned to centroid_4 are 113390
The coordinates of Centroid_5 are (2.51173989960244,0.15513211561190582, 239.52165305683926, 10.52162243726586,0.28121843773503813,0.6489416568174492,17.898678414096917)
The number of points assigned to centroid_5 are 93870
The coordinates of Centroid_6 are (1.4941300256629522,0.10790334858233555, 239.57925792308401, 6.2051086233324035,0.10102775814829967,0.40112735192141596,17.974849472896857)
The number of points assigned to centroid_6 are 241983
The coordinates of Centroid_7 are (0.41512450602167624,0.10552312244290205, 243.96493293300801, 1.7936267101832304,0.02621693981563701,0.3482657748975482,0.3821594796822067)
The number of points assigned to centroid_7 are 298433
The coordinates of Centroid_8 are (3.529498593548063,0.17834226198018246, 236.4632388409794, 14.97394896226656,0.282329388501746,0.6597146549757988,17.285167633866347)
The number of points assigned to centroid_8 are 39461
The coordinates of Centroid_9 are (0.4172959447414767,0.10452390819964484, 235.41166722370565, 1.8726693404633685,0.03954991087340286,0.35619516934046343,0.13239750446563279)
The number of points assigned to centroid_9 are 89760
The coordinates of Centroid_10 are (0.36008722463327353,0.111708191269178837, 241.75233546236495, 1.5938082988032134,0.022853131198803382,0.3887045146593877,0.4556732714097755)
The number of points assigned to centroid_10 are 407584
The coordinates of Centroid_11 are (3.9963361925232452,0.19407701733593163, 237.19867459472408, 16.885924348647357,38.102267933548944,1.6710190634981217,10.958257166388783)
The number of points assigned to centroid_11 are 49781
The coordinates of Centroid_12 are (0.3782842183602744,0.11799405369625071, 239.47183722087667, 1.691172917764908,0.02966420212944991,0.4233543884843657,0.4113084461309007)
The number of points assigned to centroid_12 are 267393
The coordinates of Centroid_13 are (2.8728976572958764,0.19423125836679897, 238.66834236947832, 12.266131191432395,0.2747991967871486,28.42801204819277,6.064056224899598)
The number of points assigned to centroid_13 are 29880
The coordinates of Centroid_14 are (2.332511160313571,0.26836036143857395, 239.00716773382842, 9.808569205912253,0.18867811621087907,0.5414996110346478,28.407037280832984)
The number of points assigned to centroid_14 are 16711
The coordinates of Centroid_15 are (0.4175395654174132,0.0917795059631214, 247.02139248681905, 1.7641929433413066,0.01545634709983367,0.2860087765863326,0.297324556747009076)
The number of points assigned to centroid_15 are 113028
The coordinates of Centroid_16 are (4.73508441952379,0.18825710883647368, 236.5969101828328, 20.06459233385409,3.75962864233845,42.74478352789779,16.25751447743359)
The number of points assigned to centroid_16 are 21758
The loss for the iteration of training is 14.702045853520298

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The coordinates of Centroid\_0 are (2.9919285097990946,0.24628374214224008,

238.192707999507, 13.39583384691235, 20.05127573030938, 0.7222975471465549,

12.626895106619006)

The number of points assigned to centroid\_0 is 8113

The coordinates of Centroid\_1 are (1.5750814746838067,0.10276555081195024,

243.42005373126435, 6.436176834378545, 0.10288074053385468, 0.3549388873372435,

18.534825572889652)

The number of points assigned to centroid\_1 is 150378

The coordinates of Centroid\_2 are (1.0549956600800043,0.2624435931628092,

240.84364626015457, 4.5891332282702, 0.04805430961328646, 0.44432052369984243,

11.006425021214692)

The number of points assigned to centroid\_2 is 41245

The coordinates of Centroid\_3 are (1.579929731010766, 0.1109134079867276,  
234.75160875103677, 6.711257257969028, 0.13135442587984358, 0.4310048583955445,  
17.040585377414384)

The number of points assigned to centroid\_3 is 67512

The coordinates of Centroid\_4 are (1.8339734897257032, 0.15720576770438138,

239.6392566363863, 7.770902195960859, 0.2476320663197813, 0.523793985360261,  
0.2933327453920099)

The number of points assigned to centroid\_4 is 113390

The coordinates of Centroid\_5 are (2.511739099602444, 0.15513211561190582,

239.52165305683926, 10.521622434726586, 0.28121843773503813, 0.6489416568174492,  
17.898678414096917)

The number of points assigned to centroid\_5 is 93070

The coordinates of Centroid\_6 are (1.4941300256629322, 0.10790334858233555,

239.57925792308401, 6.2051086233324035, 0.10102775814829967, 0.40112735192141596,  
17.974849472896857)

The number of points assigned to centroid\_6 is 241983

The coordinates of Centroid\_7 are (0.41512456062167624, 0.10552312244290205,

243.96493293300801, 1.7936267101832304, 0.02621693981563701, 0.3482657748975482,  
0.3821594796822067)

The number of points assigned to centroid\_7 is 298433

The coordinates of Centroid\_8 are (3.529498593548063, 0.17834226198018246, 236.46323889409794, 14.97394896226656, 0.2823293885101746, 0.6597146549757988, 17.285167633866347)

The number of points assigned to centroid\_8 is 39461

The coordinates of Centroid\_9 are (0.4172959447414767, 0.10452390819964484, 235.41166722370505, 1.8726693404633685, 0.039549910873440286, 0.35610516934046343, 0.13239750445632797)

The number of points assigned to centroid\_9 is 89760

The coordinates of Centroid\_10 are (0.3600722463327353, 0.11170191269170837, 241.75233546236495, 1.5938082988032134, 0.022853131198083382, 0.3887045146593877, 0.45567327140977554)

The number of points assigned to centroid\_10 is 407384

The coordinates of Centroid\_11 are (3.9963361925232452, 0.19407701733593163, 237.19867459472408, 16.885924348647357, 38.102267933548944, 1.6710190634981217, 10.958257166388783)

The number of points assigned to centroid\_11 is 49781

The coordinates of Centroid\_12 are (0.3782842183602744, 0.11799405369625071, 239.47183722087667, 1.6911729177649408, 0.02966420212944991, 0.4233543884843657, 0.41130844861309007)

The number of points assigned to centroid\_12 is 267393

The coordinates of Centroid\_13 are (2.8728976572958764, 0.19423125836679897, 238.66834236947832, 12.266131191432395, 0.2747991967871486, 28.42801204819277, 6.064056224899598)

The number of points assigned to centroid\_13 is 29880

The coordinates of Centroid\_14 are (2.332511160313571, 0.26836036143857395, 239.00716773382842, 9.808569205912253, 0.18867811621087907, 0.5414996110346478, 28.407037280832984)

The number of points assigned to centroid\_14 is 16711

The coordinates of Centroid\_15 are (0.4175395654174132, 0.0917795059631214, 247.02139248681905, 1.7641929433413066, 0.01545634709983367, 0.2860087765863326, 0.29732455674700076)

The number of points assigned to centroid\_15 is 113028

The coordinates of Centroid\_16 are (4.735048441952379, 0.18825710083647368, 236.59691010203238, 20.06459233385409, 3.75962864233845, 42.74478352789779, 16.25751447743359)

The number of points assigned to centroid\_16 is 21758

The loss for the iteration of training is 14.702045853520298

**K = 18:**

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The coordinates of Centroid_1 are (1.056925415768954,0.2628613619308158, 240.84254520806792, 4.597850347382035,0.06228666876467598,0.4446488658645816,11.018252681013823)
The number of points assigned to centroid_1 are 41309
The coordinates of Centroid_2 are (1.5935687541086523,0.11088124160402374, 234.80540600794532, 6.768848429416733,0.13486437819761626,0.4304313030554206,17.051762083059423)
The number of points assigned to centroid_2 are 69974
The coordinates of Centroid_3 are (1.6168848873245563,0.1049120061363696, 243.33382013992374, 6.614248510755295,0.11527969367619495,0.3696051565331964,18.520663866533877)
The number of points assigned to centroid_3 are 161659
The coordinates of Centroid_4 are (0.3544582228550715,0.10284845444661116, 243.66225556388893, 1.5463591242333585,0.01856969712076223,0.3362704196564606,0.39894626316002657)
The number of points assigned to centroid_4 are 320953
The coordinates of Centroid_5 are (0.3454228664231136,0.11324166940791193, 241.4333909816062, 1.5377440251547603,0.028602107869673668,0.3985837022148431,0.4587219647894073)
The number of points assigned to centroid_5 are 386077
The coordinates of Centroid_6 are (0.36616531813164643,0.10181295644407166, 235.1714478799965, 1.6578258813638513,0.03250932590763411,0.33594283612672726,0.116298087216939)
The number of points assigned to centroid_6 are 76132
The coordinates of Centroid_7 are (0.33968107128870535,0.11349177932912032, 239.17087579291672, 1.5282319966117888,0.024864257807852824,0.3994413274896379,0.3898096992019644)
The number of points assigned to centroid_7 are 210141
The coordinates of Centroid_8 are (2.884625452132095,0.19476893977102835, 238.6525120292023, 12.316987250705142,0.35407333665173385,28.34737016757923,6.167579226812676)
The number of points assigned to centroid_8 are 30135
The coordinates of Centroid_9 are (2.5368728194603567,0.17069107261423275, 238.12352115651484, 10.797054385223683,0.6640309048107684,0.5088126999456751,0.21485483189473048)
The number of points assigned to centroid_9 are 33134
The coordinates of Centroid_10 are (1.353101925371579,0.15370731994755657, 238.67583386120415, 5.77701088637753,0.18817671581986653,0.5914735648100408,0.356363154250869603)
The number of points assigned to centroid_10 are 67883
The coordinates of Centroid_11 are (3.053691272263776,0.170551983308287, 238.05890548042257, 12.899401835144683,0.7208656816094833,0.6388993238166792,17.604724935303448)
The number of points assigned to centroid_11 are 95832
The coordinates of Centroid_12 are (1.5694949252256363,0.11233775691980689, 239.55468858999652, 6.527336417119321,0.11469513929432194,0.41919656891363904,17.969199562880796)
The number of points assigned to centroid_12 are 267204
The coordinates of Centroid_13 are (2.339849235510258,0.26868092924025133, 238.99828137963777, 9.842230650705197,0.229109873177698,0.5448619177432736,28.373948885812494)
The number of points assigned to centroid_13 are 16874
The coordinates of Centroid_14 are (1.385731517851931,0.14932071876648786, 242.78978908952325, 5.830412733775011,0.2200562818784077,0.520416837661957,0.35275839831154365)
The number of points assigned to centroid_14 are 68228
The coordinates of Centroid_15 are (4.616379562760994,0.18516295750429818, 236.75117563252357, 19.54727585359857,1.474379759272906,43.2250061409973,16.374502579218866)
The number of points assigned to centroid_15 are 28355
The coordinates of Centroid_16 are (4.4109558803506885,0.2000124619620348, 236.64877611940216, 18.70827416316503,36.93725547022171,2.603245906390378,17.62944508796986)
The number of points assigned to centroid_16 are 34505
The coordinates of Centroid_17 are (3.303518924587648,0.19671522547430673, 238.06680188769116, 13.998789207741442,37.816255124416055,2.1833825912861093,0.3973686719420345)
The number of points assigned to centroid_17 are 28978
The loss for the iteration of training is 13.102981672567498

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The coordinates of Centroid\_1 are (1.056925415768954,0.2628613619308158,

240.84254520806792, 4.597850347382035, 0.06228666876467598, 0.4446488658645816,

11.018252681013823)

The number of points assigned to centroid\_1 is 41309

The coordinates of Centroid\_2 are (1.5935687541086523,0.11088124160402374,

234.80540600794532, 6.768848429416733, 0.13486437819761626, 0.4304313030554206,

17.051762083059423)

The number of points assigned to centroid\_2 is 69974

The coordinates of Centroid\_3 are (1.6168848873245563,0.1049120061363696,

243.33382013992374, 6.614248510755295, 0.11527969367619495, 0.3696051565331964,

18.520663866533877)

The number of points assigned to centroid\_3 is 161659

The coordinates of Centroid\_4 are (0.3544582228550715, 0.10284845444661116, 243.66225556388093, 1.5463591242333585, 0.01856969712076223, 0.3362704196564606, 0.39894626316002657)

The number of points assigned to centroid\_4 is 320953

The coordinates of Centroid\_5 are (0.3454228664231136, 0.11324166940791193, 241.4333909816062, 1.5377440251547603, 0.020602107869673668, 0.3985837022148431, 0.4587219647894073)

The number of points assigned to centroid\_5 is 386077

The coordinates of Centroid\_6 are (0.36616531813164643, 0.10181295644407166, 235.1714478799965, 1.6578258813638513, 0.03250932590763411, 0.33594283612672726, 0.1162980087216939)

The number of points assigned to centroid\_6 is 76132

The coordinates of Centroid\_7 are (0.33968107128070535, 0.11349177932912032, 239.17087579291672, 1.5282319966117888, 0.024864257807852824, 0.3994413274896379, 0.3898096992019644)

The number of points assigned to centroid\_7 is 210141

The coordinates of Centroid\_8 are (2.8846254521320995, 0.19476893977102835, 238.6525120292023, 12.316907250705142, 0.35407333665173385, 28.34737016757923, 6.167579226812676)

The number of points assigned to centroid\_8 is 30135

The coordinates of Centroid\_9 are (2.5368728194603567, 0.17069107261423275,  
238.12352115651484, 10.797054385223683, 0.6640309048107684, 0.5088126999456751,  
0.21485483189473048)

The number of points assigned to centroid\_9 is 33134

The coordinates of Centroid\_10 are (1.353101925371579, 0.15370731994755657,  
238.67583386120415, 5.776701088637753, 0.18817671581986653, 0.5914735648100408,  
0.35636315425069603)

The number of points assigned to centroid\_10 is 67883

The coordinates of Centroid\_11 are (3.0536912722263776, 0.1705519033308287,  
238.05890548042257, 12.899401035144603, 0.7208656816094833, 0.6388993238166792,  
17.604724935303448)

The number of points assigned to centroid\_11 is 95832

The coordinates of Centroid\_12 are (1.5694949252256363, 0.11233775691980609,  
239.55468858999652, 6.527336417119321, 0.11469513929432194, 0.41919656891363904,  
17.969199562880796)

The number of points assigned to centroid\_12 is 267204

The coordinates of Centroid\_13 are (2.339849235510258, 0.26868092924025133,  
238.9982813796377, 9.842230650705197, 0.2291098731776698, 0.5448619177432736,  
28.373948085812494)

The number of points assigned to centroid\_13 is 16874

The coordinates of Centroid\_14 are (1.385731517851931, 0.14932071876648786,  
242.78978908952325, 5.830412733775011, 0.2200562818784077, 0.520416837661957,  
0.35275839831154365)

The number of points assigned to centroid\_14 is 68228

The coordinates of Centroid\_15 are (4.616379562760994, 0.18516295750429818,  
236.75117563252357, 19.54727585359857, 1.474379759272906, 43.2250061409973,  
16.374502579218866)

The number of points assigned to centroid\_15 is 20355

The coordinates of Centroid\_16 are (4.4100955803506805, 0.2000124619620348,  
236.64877611940216, 18.70827416316503, 36.93725547022171, 2.603245906390378,  
17.62944500796986)

The number of points assigned to centroid\_16 is 34505

The coordinates of Centroid\_17 are (3.303518924587648, 0.19671522547430673,  
238.06680188769116, 13.998789207741442, 37.016255124416055, 2.1833825912861093,  
0.3973686719420345)

The number of points assigned to centroid\_17 is 20978

The loss for the iteration of training is 13.102981672567498

**K = 19:**

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The coordinates of Centroid_2 are (1.5629139673138732,0.11205825930363074, 239.53987590135986, 6.499921637770408,0.11563326476638261,0.4186991869918699,17.96700874793734)
The number of points assigned to centroid_2 are 265434
The coordinates of Centroid_3 are (3.0590958704217117,0.2484360134247763, 238.1844089922665, 13.645381584707438,18.306726980884285,0.668294761418357,15.32598861812345)
The number of points assigned to centroid_3 are 6853
The coordinates of Centroid_4 are (4.481041494163418,0.19637422568093427, 236.58129058365645, 18.96811286225713,37.963206225680935,2.821852140077821,17.61758754863813)
The number of points assigned to centroid_4 are 32125
The coordinates of Centroid_5 are (2.3299494714288975,0.2676618288239867, 239.0030968165884, 9.796953958984829,0.1620975930239583,0.47775189631487786,28.374126500627128)
The number of points assigned to centroid_5 are 16743
The coordinates of Centroid_6 are (1.6159439593283836,0.10492535510796742, 243.32311898309626, 6.618355261131934,0.10921583731320289,0.3688738252965645,18.519346787860115)
The number of points assigned to centroid_6 are 162275
The coordinates of Centroid_7 are (1.5882215650391462,0.11077499450991803, 234.7571887855939, 6.746929214552472,0.128921748041871,0.43157894736842106,17.041900300124443)
The number of points assigned to centroid_7 are 68305
The coordinates of Centroid_8 are (0.41747911843076474,0.10475863876632847, 235.48840428552504, 1.8715565069240256,0.03774409156437027,0.3599121925647634,0.1359813900659648)
The number of points assigned to centroid_8 are 91564
The coordinates of Centroid_9 are (0.3660955262090156,0.1029684581404867, 243.7605134253131, 1.5930272069571803,0.02015696701977898,0.3328340827590302,0.3945256184823882)
The number of points assigned to centroid_9 are 303121
The coordinates of Centroid_10 are (0.41289229816549206,0.09321724591686394, 246.80837487421763, 1.7476259772425866,0.015806176948680237,0.2934592466716774,0.299775524421394)
The number of points assigned to centroid_10 are 129190
The coordinates of Centroid_11 are (1.3883741032168582,0.15290052456992953, 241.3072901720256, 5.871572938363235,0.22106186839466174,0.558583947134151,0.3658875260356399)
The number of points assigned to centroid_11 are 183704
The coordinates of Centroid_12 are (0.3569355584124097,0.11557488079933978, 239.4166161250459, 1.68086151242451017,0.026240419195782006,0.4070804380726107,0.408187018789084)
The number of points assigned to centroid_12 are 245804
The coordinates of Centroid_13 are (3.3238524468707157,0.1960029245466957, 238.05938633261755, 14.05866640670692,37.38033729771885,2.2118834080717487,0.39154806080569215)
The number of points assigned to centroid_13 are 29516
The coordinates of Centroid_14 are (2.6755567972862725,0.18912407884060842, 238.74795160887984, 11.426580194562188,0.39206784734347716,30.49847842354782,0.3834871539037166)
The number of points assigned to centroid_14 are 28045
The coordinates of Centroid_15 are (1.0561598029841563,0.26265677957405775, 240.844515008484215, 4.593872216844251,0.047725072604065825,0.4487173281703775,11.011035818005809)
The number of points assigned to centroid_15 are 41320
The coordinates of Centroid_16 are (0.3410409113471468,0.11213927014545895, 241.62082580711882, 1.5172326168583705,0.019740817471621562,0.39706882040657776,0.457699404376537)
The number of points assigned to centroid_16 are 378704
The coordinates of Centroid_17 are (5.9463504854368825,0.17604902912621392, 235.47467718446626, 25.319029126213596,3.31286407766990828,69.07694174757282,12.035679611650485)
The number of points assigned to centroid_17 are 4120
The coordinates of Centroid_18 are (3.899439116623819,0.1950009075782781, 237.6192788534262, 16.53211314475862,0.6299349568900318,31.722697020117984,17.611556496747845)
The number of points assigned to centroid_18 are 26444
The loss for the iteration of training is 10.31257386167183

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The coordinates of Centroid\_0 are (2.2871032224259813,0.1650821325648404,

237.7453534625779, 9.730896864902714, 0.33311501178936337, 0.5282944720985067,

0.22428172212033884)

The number of points assigned to centroid\_0 is 45804

The coordinates of Centroid\_1 are (3.0357801258284134,0.16705204339925783,

238.07318971945807, 12.798485437300963, 0.24769717148588893, 0.6041025533300424,

17.601098635633186)

The number of points assigned to centroid\_1 is 95209

The coordinates of Centroid\_2 are (1.5629139673138732,0.11205825930363074,

239.53987590135986, 6.499921637770408, 0.11563326476638261, 0.4186991869918699,

17.96700874793734)

The number of points assigned to centroid\_2 is 265434

The coordinates of Centroid\_3 are (3.0590958704217117, 0.2484360134247763, 238.1844009922665, 13.645381584707438, 18.306726980884285, 0.660294761418357, 15.32598861812345)

The number of points assigned to centroid\_3 is 6853

The coordinates of Centroid\_4 are (4.481041494163418, 0.19637422568093427, 236.58129058365645, 18.96811206225713, 37.963206225680935, 2.821852140077821, 17.61758754863813)

The number of points assigned to centroid\_4 is 32125

The coordinates of Centroid\_5 are (2.3299494714208975, 0.2676618288239867, 239.0030968165804, 9.796953950904829, 0.1620975930239503, 0.47775189631487786, 28.374126500627128)

The number of points assigned to centroid\_5 is 16743

The coordinates of Centroid\_6 are (1.6159439593283036, 0.10492535510706742, 243.32311890309626, 6.610355261131934, 0.10921583731320289, 0.3688738252965645, 18.519346787860115)

The number of points assigned to centroid\_6 is 162275

The coordinates of Centroid\_7 are (1.5882215650391462, 0.11077499450991803, 234.7571887855939, 6.746929214552472, 0.128921748041871, 0.43157894736842106, 17.041900300124443)

The number of points assigned to centroid\_7 is 68305

The coordinates of Centroid\_8 are (0.41747911843076474, 0.10475863876632847, 235.48840428552504, 1.8715565069240256, 0.03774409156437027, 0.3599121925647634, 0.1359813900659648)

The number of points assigned to centroid\_8 is 91564

The coordinates of Centroid\_9 are (0.3660955262090156, 0.1029684581404867, 243.7605134253131, 1.5930272069571803, 0.02015696701977098, 0.3328340827590302, 0.3945256184823882)

The number of points assigned to centroid\_9 is 303121

The coordinates of Centroid\_10 are (0.41289229816549206, 0.09321724591686394, 246.80837487421763, 1.7476259772425866, 0.015806176948680237, 0.2934592460716774, 0.2997755244213948)

The number of points assigned to centroid\_10 is 129190

The coordinates of Centroid\_11 are (1.3883741032168582, 0.15290052456992953, 241.3072901720256, 5.871572938363235, 0.22106186839466174, 0.558503047134151, 0.3658875260356399)

The number of points assigned to centroid\_11 is 103704

The coordinates of Centroid\_12 are (0.3569355584124097, 0.11557488079933978, 239.4166161250459, 1.6006151242451017, 0.026240419195782006, 0.4070804380726107, 0.408187010789084)

The number of points assigned to centroid\_12 is 245804

The coordinates of Centroid\_13 are (3.3230524468707157,0.1960029245466957,  
238.05938633261755, 14.05866640670692, 37.38033729771885, 2.2118834080717487,  
0.39154806005069215)

The number of points assigned to centroid\_13 is 20516

The coordinates of Centroid\_14 are (2.6755567972062715,0.18912407084060842,  
238.74795160887984, 11.426580194562188, 0.39206784734347716, 30.49847842354702,  
0.3834871539037166)

The number of points assigned to centroid\_14 is 20045

The coordinates of Centroid\_15 are (1.0561590029041563,0.26265667957405775,  
240.84451500484215, 4.593872216844251, 0.047725072604065825, 0.4487173281703775,  
11.011035818005809)

The number of points assigned to centroid\_15 is 41320

The coordinates of Centroid\_16 are (0.3410409113471408,0.11213927014545895,  
241.62082580711882, 1.5172326168583705, 0.019740817471621562, 0.39706882040657776,  
0.4576994043765376)

The number of points assigned to centroid\_16 is 370704

The coordinates of Centroid\_17 are (5.9463504854368825,0.17604902912621392,  
235.47467718446626, 25.319029126213596, 3.3128640776699028, 69.07694174757282,  
12.035679611650485)

The number of points assigned to centroid\_17 is 4120

The coordinates of Centroid\_18 are (3.899439116623819, 0.1950009075782781,  
 237.6192788534262, 16.53211314475862, 0.6299349568900318, 31.722697020117984,  
 17.611556496747845)

The number of points assigned to centroid\_18 is 26444

The loss for the iteration of training is 10.31257386167183

## K = 20:

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The coordinates of Centroid_3 are (3.8840758691752977, 0.1946551921535697, 237.6411494866997, 16.464137694157053, 0.46788535663855285, 31.679655001335725, 17.613517536159982)
The number of points assigned to centroid_3 are 26203
The coordinates of Centroid_4 are (1.0563491831971932, 0.2628555523142763, 240.83884237650994, 4.594734539089956, 0.061649163749513805, 0.44647024504084015, 11.025549397121743)
The number of points assigned to centroid_4 are 4136
The coordinates of Centroid_5 are (1.5755709829218899, 0.10287484798815273, 243.4098417094064, 6.438588536986312, 0.10443874583619732, 0.35589938137788824, 18.533508697721143)
The number of points assigned to centroid_5 are 151304
The coordinates of Centroid_6 are (2.289451618882149, 0.16785124194399112, 237.55222471961687, 9.774445540239961, 0.7061076580812367, 0.5433828325221899, 0.22838925712713012)
The number of points assigned to centroid_6 are 43601
The coordinates of Centroid_7 are (2.532019817683963, 0.15589405086334132, 239.50575718732995, 10.614362807931947, 0.3958658724430992, 0.6055559744498422, 17.894427868199102)
The number of points assigned to centroid_7 are 92837
The coordinates of Centroid_8 are (0.28987061778539335, 0.09561764283953861, 240.6372951250887, 1.2916108507245176, 0.01375335189674135, 0.2591618510930218, 0.4325813559134999)
The number of points assigned to centroid_8 are 271861
The coordinates of Centroid_9 are (3.9234537206106537, 0.19722154245806894, 237.26145341942285, 16.62592850554402, 37.1180279728178, 1.2592662311992922, 11.124898819720272)
The number of points assigned to centroid_9 are 53123
The coordinates of Centroid_10 are (1.5076266737403808, 0.14823991142583745, 241.3163504676668, 6.355825942542044, 0.2419758497007162, 0.41323076568212486, 0.3388349914078448)
The number of points assigned to centroid_10 are 86707
The coordinates of Centroid_11 are (0.30177062442388183, 0.08738999779801192, 242.6838448668124, 1.3194776923448963, 0.01263849205911446, 0.18735268269184804, 0.4206150463141715)
The number of points assigned to centroid_11 are 271947
The coordinates of Centroid_12 are (2.3315858477011564, 0.2685949473180826, 239.00628532088163, 9.886082375478901, 0.24281609195402298, 0.4750359195402299, 28.406190134099617)
The number of points assigned to centroid_12 are 16784
The coordinates of Centroid_13 are (2.666268136272533, 0.188881863772745466, 238.7609624248494, 11.385981803607174, 0.3016533066132265, 0.462725450901884, 0.38301603206412826)
The number of points assigned to centroid_13 are 19960
The coordinates of Centroid_14 are (0.39078142698778634, 0.1015320467600509, 244.70813942355846, 1.683936309584161, 0.020860626826564546, 0.32679633175450973, 0.3467348584097551)
The number of points assigned to centroid_14 are 198460
The coordinates of Centroid_15 are (0.4264830267155169, 0.1220282854094294, 238.4715211053206, 1.903935627247008, 0.03906403974365073, 0.4364257898778739, 0.3492113114453287)
The number of points assigned to centroid_15 are 147243
The coordinates of Centroid_16 are (0.4124874487934033, 0.09122188899807272, 247.55547582281898, 1.739593409818658, 0.012978726119526794, 0.2821628657844026, 0.2968133845505941)
The number of points assigned to centroid_16 are 78359
The coordinates of Centroid_17 are (1.498545105407974, 0.10822747112102596, 239.56581583093347, 6.224217314254877, 0.10050210028878971, 0.4022750393804148, 17.971957862956156)
The number of points assigned to centroid_17 are 243776
The coordinates of Centroid_18 are (6.017132443047909, 0.19584351924587584, 235.2308279654362, 25.637957580518453, 14.574234092694423, 57.63519245875884, 12.100549882168107)
The number of points assigned to centroid_18 are 6365
The coordinates of Centroid_19 are (0.6094498113592035, 0.19461082595611215, 241.8151256855027, 2.7161223887029218, 0.058823529411764705, 1.1674103757393852, 0.5421758878609118)
The number of points assigned to centroid_19 are 125273
The loss for the iteration of training is 12.508318699425353
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The coordinates of Centroid\_0 are (0.3988591392914724, 0.10270203852018542,  
 234.9095409258453, 1.7978386060487863, 0.03441945846718678, 0.34731824305319103,  
 0.11258493834105612)

The number of points assigned to centroid\_0 is 67549

The coordinates of Centroid\_1 are (1.5844581020510977, 0.11115533260114495,  
234.7361690759592, 6.731102140164518, 0.13029475496452847, 0.4322330731099172,  
17.03735640713586)

The number of points assigned to centroid\_1 is 67378

The coordinates of Centroid\_2 are (3.537126382785266, 0.18286250441986068,  
236.47599030156107, 15.044239026115049, 1.1188816487346567, 0.6004950244986614,  
17.304995706420165)

The number of points assigned to centroid\_2 is 39594

The coordinates of Centroid\_3 are (3.8840758691752977, 0.1946551921535697,  
237.6411494866997, 16.464137694157053, 0.46788535663855285, 31.679655001335725,  
17.613517536159982)

The number of points assigned to centroid\_3 is 26203

The coordinates of Centroid\_4 are (1.0563491831971932, 0.2628555523142763,  
240.83884237650904, 4.594734539089956, 0.061649163749513805, 0.44647024504084015,  
11.025549397121743)

The number of points assigned to centroid\_4 is 41136

The coordinates of Centroid\_5 are (1.5755709829218099, 0.10287484798815273,  
243.4098417094064, 6.438588536986312, 0.10443874583619732, 0.35589938137788824,  
18.533508697721143)

The number of points assigned to centroid\_5 is 151304

The coordinates of Centroid\_6 are (2.289451618082149, 0.16785124194399112,  
237.55222471961687, 9.774445540239961, 0.7061076580812367, 0.5433820325221899,  
0.22838925712713012)

The number of points assigned to centroid\_6 is 43601

The coordinates of Centroid\_7 are (2.532019819683963, 0.15589405086334132,  
239.50575718732995, 10.614362807931947, 0.3958658724430992, 0.6055559744498422,  
17.894427868199102)

The number of points assigned to centroid\_7 is 92837

The coordinates of Centroid\_8 are (0.28987061770539335, 0.09561764283953861,  
240.6372951250887, 1.2916100507245176, 0.01375335189674135, 0.2591618510930218,  
0.4325813559134999)

The number of points assigned to centroid\_8 is 271861

The coordinates of Centroid\_9 are (3.9234537206106537, 0.19722154245806894,  
237.26145341942285, 16.62592850554402, 37.1180279728178, 1.2592662311992922,  
11.124898819720272)

The number of points assigned to centroid\_9 is 53123

The coordinates of Centroid\_10 are (1.5076266737403008, 0.14823991142583745,  
241.3163504676668, 6.355825942542044, 0.2419758497007162, 0.41323076568212486,  
0.3380349914078448)

The number of points assigned to centroid\_10 is 86707

The coordinates of Centroid\_11 are (0.30177062442308183, 0.08730999790401192,  
242.6838448668124, 1.3194776923448963, 0.01263849205911446, 0.18735268269184804,  
0.4206150463141715)

The number of points assigned to centroid\_11 is 271947

The coordinates of Centroid\_12 are (2.3315858477011564, 0.26859494731800826,  
239.00628532088163, 9.806082375478901, 0.24281609195402298, 0.4750359195402299,  
28.406190134099617)

The number of points assigned to centroid\_12 is 16704

The coordinates of Centroid\_13 are (2.666268136272533, 0.18888186372745466,  
238.7609624248494, 11.385901803607174, 0.3016533066132265, 30.462725450901804,  
0.38301603206412826)

The number of points assigned to centroid\_13 is 19960

The coordinates of Centroid\_14 are (0.39078142698778634, 0.1015320467600509,  
244.70813942355846, 1.683936309584161, 0.020860626826564546, 0.32679633175450973,  
0.3467348584097551)

The number of points assigned to centroid\_14 is 198460

The coordinates of Centroid\_15 are (0.4264830267155109, 0.1220282854094294,  
238.4715211053206, 1.903935627247008, 0.03906403974365073, 0.4364257898778739,  
0.3492113114453287)

The number of points assigned to centroid\_15 is 147143

The coordinates of Centroid\_16 are (0.4124874487934033, 0.09122188899807272, 247.55547582281898, 1.739593409818658, 0.012978726119526794, 0.2821628657844026, 0.2968133845505941)

The number of points assigned to centroid\_16 is 78359

The coordinates of Centroid\_17 are (1.4985454105407974, 0.10822747112102596, 239.56581583093347, 6.224217314254877, 0.10050210028878971, 0.4022750393804148, 17.971957862956156)

The number of points assigned to centroid\_17 is 243776

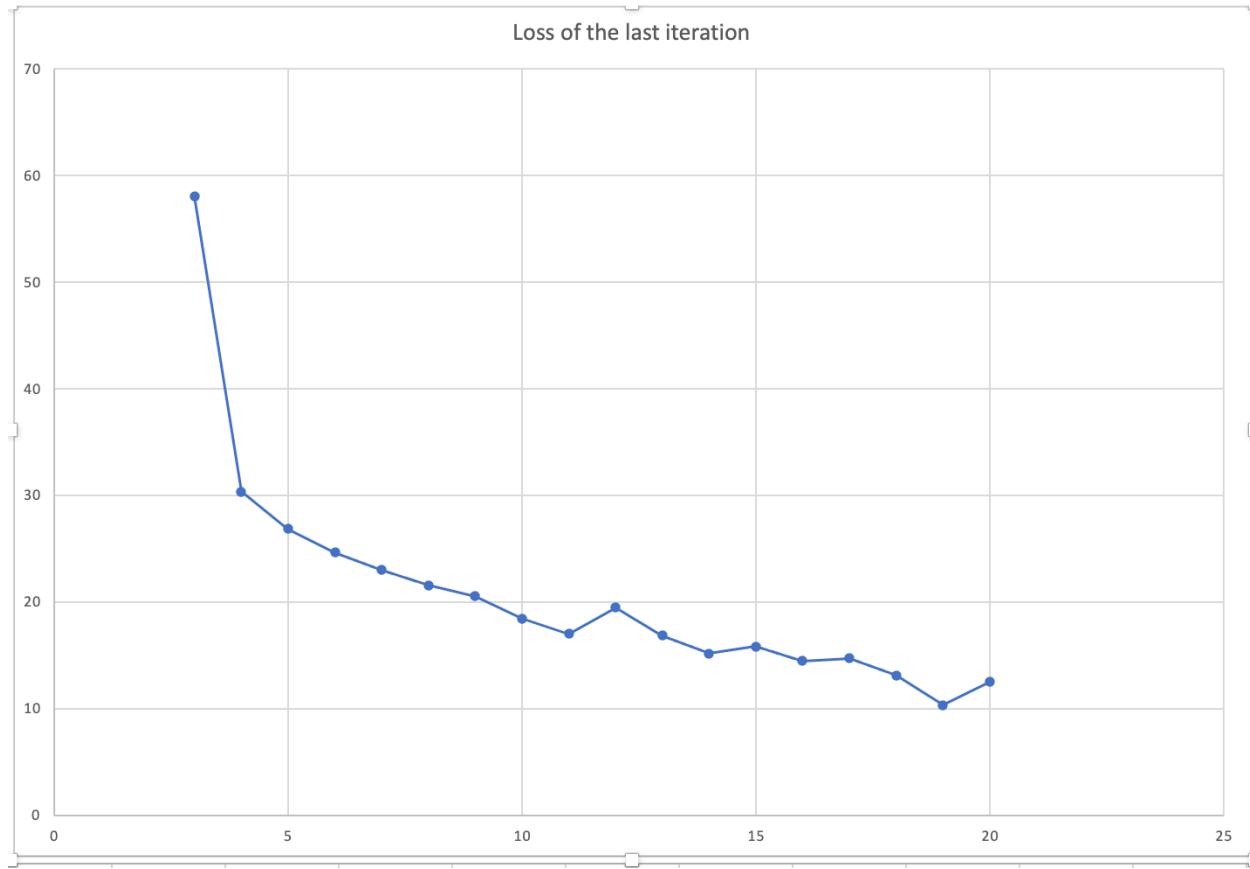
The coordinates of Centroid\_18 are (6.017132443047909, 0.19584351924587584, 235.2308279654362, 25.637957580518453, 14.574234092694423, 57.63519245875884, 12.100549882168107)

The number of points assigned to centroid\_18 is 6365

The coordinates of Centroid\_19 are (0.6094490113592035, 0.19461082595611215, 241.8151256855027, 2.7161223887029218, 0.058823529411764705, 1.1674103757393852, 0.5421758878609118)

The number of points assigned to centroid\_19 is 125273

The loss for the iteration of training is 12.504318699425353



Using the elbow method, we can see from the picture that from 3-4, the loss decreases dramatically, and from 4-20, the losses are relatively steady. So, K = 4 best fits the data provided.

**Explain the stopping criteria you selected for your algorithm (see Resources) and how they may impact your results.**

The stopping criteria is that for every K, I will make thirty iterations. Because even k-means doesn't converge, the program won't run endlessly. Apart from that, the program might not produce minimum loss before it stops and thus the losses might be higher than normal.

**Explain the centroid initialization method you selected and how that may impact your results.**

For centroid initialization, I randomly choose k points from dataset. And I will iterate ten times and record every result, pick the minimum one to become my result. If I just pick once, the different centroid might be closer to each other resulting in inaccurate results. But ten times might not be enough for us to get a precise result, it might still lead to higher losses.

**Explain why your algorithm may require different amounts of time to run on the same input and parameters.**

Because for every time we get different initializations of centroids, if the initializations fit the data, we can consume less time to compute a better result. But if the initializations are close to each other, it takes a large amount of time to get the result.

**Explain why your algorithm may produce different results on the same input and parameters.**

Because for every time we get different initializations of centroids, if the initializations fit the data, we can get a relatively small loss for the input. But if the initializations are close to each other, it might produce bigger loss compared to accurate result.