# COMP3340 Data Mining Assignment 1


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## Q1)

### a)

***These Matrices were written to excel using write.csv() in R if the full files are needed please notify me.***

Hamming Distance matrix between all pairs of elections:

| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Years | 1864 | 1868 | 1872 | 1880 | 1888 | 1900 | 1904 | 1908 | 1916 | 1924 | 1928 | 1936 | 1940 | 1944 | 1948 | 1956 | 1964 | 1972 | 1860 | 1876 | 1884 | 1892 | 1896 |
| 1864 | 0 | 5 | 6 | 5 | 2 | 5 | 6 | 5 | 1 | 5 | 6 | 5 | 6 | 5 | 4 | 5 | 3 | 0 | 6 | 8 | 6 | 2 | 4 |
| 1868 | 5 | 0 | 3 | 4 | 7 | 6 | 3 | 4 | 6 | 6 | 3 | 4 | 3 | 2 | 5 | 4 | 6 | 5 | 5 | 7 | 3 | 7 | 5 |
| 1872 | 6 | 3 | 0 | 5 | 4 | 3 | 0 | 5 | 5 | 5 | 2 | 3 | 2 | 1 | 4 | 1 | 3 | 6 | 6 | 6 | 4 | 8 | 8 |
| 1880 | 5 | 4 | 5 | 0 | 5 | 6 | 5 | 4 | 4 | 6 | 3 | 6 | 5 | 4 | 5 | 6 | 4 | 5 | 3 | 5 | 3 | 7 | 5 |
| 1888 | 2 | 7 | 4 | 5 | 0 | 3 | 4 | 5 | 1 | 5 | 4 | 5 | 6 | 5 | 4 | 3 | 1 | 2 | 6 | 6 | 6 | 4 | 6 |
| 1900 | 5 | 6 | 3 | 6 | 3 | 0 | 3 | 6 | 4 | 4 | 3 | 4 | 5 | 4 | 5 | 2 | 2 | 5 | 7 | 7 | 7 | 5 | 9 |
| 1904 | 6 | 3 | 0 | 5 | 4 | 3 | 0 | 5 | 5 | 5 | 2 | 3 | 2 | 1 | 4 | 1 | 3 | 6 | 6 | 6 | 4 | 8 | 8 |
| 1908 | 5 | 4 | 5 | 4 | 5 | 6 | 5 | 0 | 4 | 6 | 3 | 4 | 3 | 4 | 3 | 6 | 6 | 5 | 7 | 3 | 7 | 7 | 5 |
| 1916 | 1 | 6 | 5 | 4 | 1 | 4 | 5 | 4 | 0 | 4 | 5 | 4 | 5 | 4 | 3 | 4 | 2 | 1 | 7 | 7 | 7 | 3 | 5 |
| 1924 | 5 | 6 | 5 | 6 | 5 | 4 | 5 | 6 | 4 | 0 | 5 | 4 | 5 | 4 | 3 | 4 | 4 | 5 | 7 | 7 | 9 | 5 | 9 |
| 1928 | 6 | 3 | 2 | 3 | 4 | 3 | 2 | 3 | 5 | 5 | 0 | 5 | 4 | 3 | 4 | 3 | 3 | 6 | 4 | 4 | 4 | 8 | 8 |
| 1936 | 5 | 4 | 3 | 6 | 5 | 4 | 3 | 4 | 4 | 4 | 5 | 0 | 1 | 2 | 5 | 2 | 4 | 5 | 9 | 7 | 7 | 7 | 5 |
| 1940 | 6 | 3 | 2 | 5 | 6 | 5 | 2 | 3 | 5 | 5 | 4 | 1 | 0 | 1 | 4 | 3 | 5 | 6 | 8 | 6 | 6 | 8 | 6 |
| 1944 | 5 | 2 | 1 | 4 | 5 | 4 | 1 | 4 | 4 | 4 | 3 | 2 | 1 | 0 | 3 | 2 | 4 | 5 | 7 | 7 | 5 | 7 | 7 |
| 1948 | 4 | 5 | 4 | 5 | 4 | 5 | 4 | 3 | 3 | 3 | 4 | 5 | 4 | 3 | 0 | 5 | 5 | 4 | 6 | 6 | 8 | 4 | 8 |
| 1956 | 5 | 4 | 1 | 6 | 3 | 2 | 1 | 6 | 4 | 4 | 3 | 2 | 3 | 2 | 5 | 0 | 2 | 5 | 7 | 7 | 5 | 7 | 7 |
| 1964 | 3 | 6 | 3 | 4 | 1 | 2 | 3 | 6 | 2 | 4 | 3 | 4 | 5 | 4 | 5 | 2 | 0 | 3 | 5 | 7 | 5 | 5 | 7 |
| 1972 | 0 | 5 | 6 | 5 | 2 | 5 | 6 | 5 | 1 | 5 | 6 | 5 | 6 | 5 | 4 | 5 | 3 | 0 | 6 | 8 | 6 | 2 | 4 |
| 1860 | 6 | 5 | 6 | 3 | 6 | 7 | 6 | 7 | 7 | 7 | 4 | 9 | 8 | 7 | 6 | 7 | 5 | 6 | 0 | 6 | 2 | 6 | 6 |
| 1876 | 8 | 7 | 6 | 5 | 6 | 7 | 6 | 3 | 7 | 7 | 4 | 7 | 6 | 7 | 6 | 7 | 7 | 8 | 6 | 0 | 6 | 10 | 6 |
| 1884 | 6 | 3 | 4 | 3 | 6 | 7 | 4 | 7 | 7 | 9 | 4 | 7 | 6 | 5 | 8 | 5 | 5 | 6 | 2 | 6 | 0 | 8 | 4 |
| 1892 | 2 | 7 | 8 | 7 | 4 | 5 | 8 | 7 | 3 | 5 | 8 | 7 | 8 | 7 | 4 | 7 | 5 | 2 | 6 | 10 | 8 | 0 | 6 |
| 1896 | 4 | 5 | 8 | 5 | 6 | 9 | 8 | 5 | 5 | 9 | 8 | 5 | 6 | 7 | 8 | 7 | 7 | 4 | 6 | 6 | 4 | 6 | 0 |
| 1912 | 7 | 6 | 3 | 4 | 5 | 4 | 3 | 6 | 6 | 4 | 3 | 6 | 5 | 4 | 3 | 4 | 4 | 7 | 3 | 5 | 5 | 7 | 9 |
| 1920 | 4 | 5 | 8 | 3 | 6 | 9 | 8 | 3 | 5 | 9 | 6 | 7 | 6 | 7 | 6 | 9 | 7 | 4 | 4 | 4 | 4 | 6 | 2 |
| 1932 | 5 | 6 | 5 | 8 | 5 | 4 | 5 | 4 | 6 | 8 | 5 | 6 | 5 | 6 | 5 | 6 | 6 | 5 | 7 | 5 | 7 | 5 | 7 |
| 1952 | 7 | 8 | 7 | 4 | 5 | 6 | 7 | 6 | 6 | 8 | 5 | 10 | 9 | 8 | 7 | 8 | 6 | 7 | 5 | 3 | 5 | 7 | 7 |
| 1960 | 7 | 6 | 5 | 6 | 5 | 4 | 5 | 2 | 6 | 8 | 3 | 6 | 5 | 6 | 5 | 6 | 6 | 7 | 7 | 3 | 7 | 7 | 7 |
| 1968 | 6 | 3 | 6 | 3 | 8 | 7 | 6 | 5 | 7 | 5 | 4 | 7 | 6 | 5 | 4 | 7 | 7 | 6 | 2 | 6 | 4 | 6 | 6 |
| 1976 | 6 | 7 | 4 | 5 | 4 | 5 | 4 | 5 | 5 | 5 | 4 | 7 | 6 | 5 | 4 | 5 | 5 | 6 | 6 | 2 | 6 | 8 | 8 |
| 1980 | 8 | 11 | 8 | 7 | 6 | 5 | 8 | 9 | 7 | 5 | 8 | 7 | 8 | 9 | 8 | 7 | 5 | 8 | 6 | 6 | 8 | 6 | 8 |

Jaccard Distance matrix between all pairs of elections:

| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Years | 1864 | 1868 | 1872 | 1880 | 1888 | 1900 | 1904 | 1908 | 1916 | 1924 | 1928 | 1936 | 1940 | 1944 | 1948 | 1956 | 1964 | 1972 | 1860 | 1876 | 1884 | 1892 | 1896 |
| 1864 | 0 | 0.714286 | 0.857143 | 0.833333 | 0.666667 | 0.833333 | 0.857143 | 0.833333 | 0.333333 | 0.714286 | 1 | 0.714286 | 0.75 | 0.714286 | 0.666667 | 0.833333 | 0.75 | 0 | 0.857143 | 1 | 0.857143 | 0.4 | 0.666667 |
| 1868 | 0.714286 | 0 | 0.428571 | 0.571429 | 1 | 0.75 | 0.428571 | 0.571429 | 0.857143 | 0.666667 | 0.5 | 0.5 | 0.375 | 0.285714 | 0.625 | 0.571429 | 0.857143 | 0.714286 | 0.625 | 0.777778 | 0.428571 | 0.777778 | 0.625 |
| 1872 | 0.857143 | 0.428571 | 0 | 0.714286 | 0.8 | 0.5 | 0 | 0.714286 | 0.833333 | 0.625 | 0.4 | 0.428571 | 0.285714 | 0.166667 | 0.571429 | 0.2 | 0.6 | 0.857143 | 0.75 | 0.75 | 0.571429 | 0.888889 | 0.888889 |
| 1880 | 0.833333 | 0.571429 | 0.714286 | 0 | 1 | 0.857143 | 0.714286 | 0.666667 | 0.8 | 0.75 | 0.6 | 0.75 | 0.625 | 0.571429 | 0.714286 | 0.857143 | 0.8 | 0.833333 | 0.5 | 0.714286 | 0.5 | 0.875 | 0.714286 |
| 1888 | 0.666667 | 1 | 0.8 | 1 | 0 | 0.75 | 0.8 | 1 | 0.5 | 0.833333 | 1 | 0.833333 | 0.857143 | 0.833333 | 0.8 | 0.75 | 0.5 | 0.666667 | 1 | 1 | 1 | 0.8 | 1 |
| 1900 | 0.833333 | 0.75 | 0.5 | 0.857143 | 0.75 | 0 | 0.5 | 0.857143 | 0.8 | 0.571429 | 0.6 | 0.571429 | 0.625 | 0.571429 | 0.714286 | 0.4 | 0.5 | 0.833333 | 0.875 | 0.875 | 0.875 | 0.714286 | 1 |
| 1904 | 0.857143 | 0.428571 | 0 | 0.714286 | 0.8 | 0.5 | 0 | 0.714286 | 0.833333 | 0.625 | 0.4 | 0.428571 | 0.285714 | 0.166667 | 0.571429 | 0.2 | 0.6 | 0.857143 | 0.75 | 0.75 | 0.571429 | 0.888889 | 0.888889 |
| 1908 | 0.833333 | 0.571429 | 0.714286 | 0.666667 | 1 | 0.857143 | 0.714286 | 0 | 0.8 | 0.75 | 0.6 | 0.571429 | 0.428571 | 0.571429 | 0.5 | 0.857143 | 1 | 0.833333 | 0.875 | 0.5 | 0.875 | 0.875 | 0.714286 |
| 1916 | 0.333333 | 0.857143 | 0.833333 | 0.8 | 0.5 | 0.8 | 0.833333 | 0.8 | 0 | 0.666667 | 1 | 0.666667 | 0.714286 | 0.666667 | 0.6 | 0.8 | 0.666667 | 0.333333 | 1 | 1 | 1 | 0.6 | 0.833333 |
| 1924 | 0.714286 | 0.666667 | 0.625 | 0.75 | 0.833333 | 0.571429 | 0.625 | 0.75 | 0.666667 | 0 | 0.714286 | 0.5 | 0.555556 | 0.5 | 0.428571 | 0.571429 | 0.666667 | 0.714286 | 0.777778 | 0.777778 | 0.9 | 0.625 | 0.9 |
| 1928 | 1 | 0.5 | 0.4 | 0.6 | 1 | 0.6 | 0.4 | 0.6 | 1 | 0.714286 | 0 | 0.714286 | 0.571429 | 0.5 | 0.666667 | 0.6 | 0.75 | 1 | 0.666667 | 0.666667 | 0.666667 | 1 | 1 |
| 1936 | 0.714286 | 0.5 | 0.428571 | 0.75 | 0.833333 | 0.571429 | 0.428571 | 0.571429 | 0.666667 | 0.5 | 0.714286 | 0 | 0.142857 | 0.285714 | 0.625 | 0.333333 | 0.666667 | 0.714286 | 0.9 | 0.777778 | 0.777778 | 0.777778 | 0.625 |
| 1940 | 0.75 | 0.375 | 0.285714 | 0.625 | 0.857143 | 0.625 | 0.285714 | 0.428571 | 0.714286 | 0.555556 | 0.571429 | 0.142857 | 0 | 0.142857 | 0.5 | 0.428571 | 0.714286 | 0.75 | 0.8 | 0.666667 | 0.666667 | 0.8 | 0.666667 |
| 1944 | 0.714286 | 0.285714 | 0.166667 | 0.571429 | 0.833333 | 0.571429 | 0.166667 | 0.571429 | 0.666667 | 0.5 | 0.5 | 0.285714 | 0.142857 | 0 | 0.428571 | 0.333333 | 0.666667 | 0.714286 | 0.777778 | 0.777778 | 0.625 | 0.777778 | 0.777778 |
| 1948 | 0.666667 | 0.625 | 0.571429 | 0.714286 | 0.8 | 0.714286 | 0.571429 | 0.5 | 0.6 | 0.428571 | 0.666667 | 0.625 | 0.5 | 0.428571 | 0 | 0.714286 | 0.833333 | 0.666667 | 0.75 | 0.75 | 0.888889 | 0.571429 | 0.888889 |
| 1956 | 0.833333 | 0.571429 | 0.2 | 0.857143 | 0.75 | 0.4 | 0.2 | 0.857143 | 0.8 | 0.571429 | 0.6 | 0.333333 | 0.428571 | 0.333333 | 0.714286 | 0 | 0.5 | 0.833333 | 0.875 | 0.875 | 0.714286 | 0.875 | 0.875 |
| 1964 | 0.75 | 0.857143 | 0.6 | 0.8 | 0.5 | 0.5 | 0.6 | 1 | 0.666667 | 0.666667 | 0.75 | 0.666667 | 0.714286 | 0.666667 | 0.833333 | 0.5 | 0 | 0.75 | 0.833333 | 1 | 0.833333 | 0.833333 | 1 |
| 1972 | 0 | 0.714286 | 0.857143 | 0.833333 | 0.666667 | 0.833333 | 0.857143 | 0.833333 | 0.333333 | 0.714286 | 1 | 0.714286 | 0.75 | 0.714286 | 0.666667 | 0.833333 | 0.75 | 0 | 0.857143 | 1 | 0.857143 | 0.4 | 0.666667 |
| 1860 | 0.857143 | 0.625 | 0.75 | 0.5 | 1 | 0.875 | 0.75 | 0.875 | 1 | 0.777778 | 0.666667 | 0.9 | 0.8 | 0.777778 | 0.75 | 0.875 | 0.833333 | 0.857143 | 0 | 0.75 | 0.333333 | 0.75 | 0.75 |
| 1876 | 1 | 0.777778 | 0.75 | 0.714286 | 1 | 0.875 | 0.75 | 0.5 | 1 | 0.777778 | 0.666667 | 0.777778 | 0.666667 | 0.777778 | 0.75 | 0.875 | 1 | 1 | 0.75 | 0 | 0.75 | 1 | 0.75 |
| 1884 | 0.857143 | 0.428571 | 0.571429 | 0.5 | 1 | 0.875 | 0.571429 | 0.875 | 1 | 0.9 | 0.666667 | 0.777778 | 0.666667 | 0.625 | 0.888889 | 0.714286 | 0.833333 | 0.857143 | 0.333333 | 0.75 | 0 | 0.888889 | 0.571429 |
| 1892 | 0.4 | 0.777778 | 0.888889 | 0.875 | 0.8 | 0.714286 | 0.888889 | 0.875 | 0.6 | 0.625 | 1 | 0.777778 | 0.8 | 0.777778 | 0.571429 | 0.875 | 0.833333 | 0.4 | 0.75 | 1 | 0.888889 | 0 | 0.75 |
| 1896 | 0.666667 | 0.625 | 0.888889 | 0.714286 | 1 | 1 | 0.888889 | 0.714286 | 0.833333 | 0.9 | 1 | 0.625 | 0.666667 | 0.777778 | 0.888889 | 0.875 | 1 | 0.666667 | 0.75 | 0.75 | 0.571429 | 0.75 | 0 |
| 1912 | 0.875 | 0.666667 | 0.428571 | 0.571429 | 0.833333 | 0.571429 | 0.428571 | 0.75 | 0.857143 | 0.5 | 0.5 | 0.666667 | 0.555556 | 0.5 | 0.428571 | 0.571429 | 0.666667 | 0.875 | 0.428571 | 0.625 | 0.625 | 0.777778 | 0.9 |
| 1920 | 0.666667 | 0.625 | 0.888889 | 0.5 | 1 | 1 | 0.888889 | 0.5 | 0.833333 | 0.9 | 0.857143 | 0.777778 | 0.666667 | 0.777778 | 0.75 | 1 | 1 | 0.666667 | 0.571429 | 0.571429 | 0.571429 | 0.75 | 0.333333 |
| 1932 | 0.714286 | 0.666667 | 0.625 | 0.888889 | 0.833333 | 0.571429 | 0.625 | 0.571429 | 0.857143 | 0.8 | 0.714286 | 0.666667 | 0.555556 | 0.666667 | 0.625 | 0.75 | 0.857143 | 0.714286 | 0.777778 | 0.625 | 0.777778 | 0.625 | 0.777778 |
| 1952 | 1 | 0.888889 | 0.875 | 0.666667 | 1 | 0.857143 | 0.875 | 0.857143 | 1 | 0.888889 | 0.833333 | 1 | 0.9 | 0.888889 | 0.875 | 1 | 1 | 1 | 0.714286 | 0.5 | 0.714286 | 0.875 | 0.875 |
| 1960 | 1 | 0.75 | 0.714286 | 0.857143 | 1 | 0.666667 | 0.714286 | 0.4 | 1 | 0.888889 | 0.6 | 0.75 | 0.625 | 0.75 | 0.714286 | 0.857143 | 1 | 1 | 0.875 | 0.5 | 0.875 | 0.875 | 0.875 |
| 1968 | 0.75 | 0.375 | 0.666667 | 0.428571 | 1 | 0.777778 | 0.666667 | 0.625 | 0.875 | 0.555556 | 0.571429 | 0.7 | 0.6 | 0.555556 | 0.5 | 0.777778 | 0.875 | 0.75 | 0.285714 | 0.666667 | 0.5 | 0.666667 | 0.666667 |
| 1976 | 0.857143 | 0.777778 | 0.571429 | 0.714286 | 0.8 | 0.714286 | 0.571429 | 0.714286 | 0.833333 | 0.625 | 0.666667 | 0.777778 | 0.666667 | 0.625 | 0.571429 | 0.714286 | 0.833333 | 0.857143 | 0.75 | 0.333333 | 0.75 | 0.888889 | 0.888889 |
| 1980 | 0.888889 | 0.916667 | 0.8 | 0.777778 | 0.857143 | 0.625 | 0.8 | 0.9 | 0.875 | 0.555556 | 0.888889 | 0.7 | 0.727273 | 0.818182 | 0.8 | 0.777778 | 0.714286 | 0.888889 | 0.666667 | 0.666667 | 0.8 | 0.666667 | 0.8 |

Function “hamJaccRowMatrix” returns both matrices above. The Hamming Distance matrix between all pairs of elections and the matrix generated by the Jaccard measure were constructed by firstly reading in the US Presidency data into Rstudio and then removing the Target column from the dataset as it was not required for analysis. Then an empty matrix was constructed using the dimensions of the US Presidency dataset and the years column was used as the names of the columns and rows of the new matrix, then the years column of the US Presidency dataset was

removed. The empty matrix “emptyMat” was assigned to 2 new variables which will be used to store the values of the final matrices; “hammyMat”,”jaccMat”. Two variables i and j were assigned 1 before a nested while loop was constructed where the outer loop is executed while i is less than the number of rows of emptyMat +1 (since we’re starting at 1) and i is incremented by 1 after the inner loop completes its first cycle, the inner loop is executed while j is less than the number of columns of emptyMat +1 and within the innerloop we call the functions “hammyDist” and “jaccDist” which take took arguments of the rows of the US Presidency dataset and will calculate the hamming distances and jaccard distances between the first row and all the rows of US Presidency dataset and then do that process again for the next row once the outer loop has incremented whilst ultimately assigning these values to the new matrices “hammyMat” and “jaccMat” filling them up column by column since in the inner loop the row index for the matrices “hammyMat” and “jaccMat” stay the same until the condition for the inner while breaks whilst the column index is incrementing in the inner loop. Then a list consisting of the two matrices was created and the function “hamJaccRowMatrix” returns that list whenever called.

Hamming and Jaccard distance calculation’s function Descriptions:

“hammyDist” has two parameters (binA and binB) which in our case will be binary data strings (either columns or rows from the US presidency dataset) of the same length. The hamming distance is calculated by taking the sum of the inequality operator between the 2 binary data strings, the inequality operator will check to see if the value is equal for each binary attribute in the same position in which the two binary attributes differ, we get a value of 1 and sum these values up for each differing binary attribute in a particular position and then the summed value is returned.

“jaccDist” has two parameters (bin1 and bin2) which in our case will be binary data strings (either columns or rows from the US presidency dataset) of the same length. Firstly, we add each pair of binary attributes together from the binary data string and whenever they are equal to 2 (we check if they are equal to 2 using relational operator ==) it means each pair of attributes are both equal to 1 and we take the sum all those resultant true values and assign to variable “inters”. Now we do the same process except we set the relational operator == to 1 to check the number of times in which only one of the binary attributes is 1 and we sum all those resultant true values and then add the previous variable “inters” and assign to variable “join”. Finally, we divide the “join” variable by the “inters” variable and subtract the result of that division from 1 to find the dissimilarity.

**b)**

***These Matrices were written to excel using write.csv() in R if the full files are needed please notify me.***

Hamming distance matrix between columns of US Presidency dataset:

| | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q1 | 0 | 9 | 18 | 12 | 22 | 16 | 14 | 18 | 17 | 18 | 16 | 19 |
| Q2 | 9 | 0 | 17 | 21 | 13 | 15 | 11 | 17 | 22 | 17 | 13 | 18 |
| Q3 | 18 | 17 | 0 | 10 | 16 | 14 | 14 | 14 | 11 | 8 | 16 | 9 |
| Q4 | 12 | 21 | 10 | 0 | 24 | 12 | 16 | 18 | 11 | 8 | 16 | 13 |
| Q5 | 22 | 13 | 16 | 24 | 0 | 20 | 14 | 16 | 21 | 18 | 16 | 17 |
| Q6 | 16 | 15 | 14 | 12 | 20 | 0 | 20 | 14 | 13 | 10 | 12 | 9 |
| Q7 | 14 | 11 | 14 | 16 | 14 | 20 | 0 | 18 | 19 | 18 | 10 | 19 |
| Q8 | 18 | 17 | 14 | 18 | 16 | 14 | 18 | 0 | 11 | 18 | 14 | 19 |
| Q9 | 17 | 22 | 11 | 11 | 21 | 13 | 19 | 11 | 0 | 15 | 13 | 12 |
| Q10 | 18 | 17 | 8 | 8 | 18 | 10 | 18 | 18 | 15 | 0 | 14 | 7 |
| Q11 | 16 | 13 | 16 | 16 | 16 | 12 | 10 | 14 | 13 | 14 | 0 | 15 |
| Q12 | 19 | 18 | 9 | 13 | 17 | 9 | 19 | 19 | 12 | 7 | 15 | 0 |

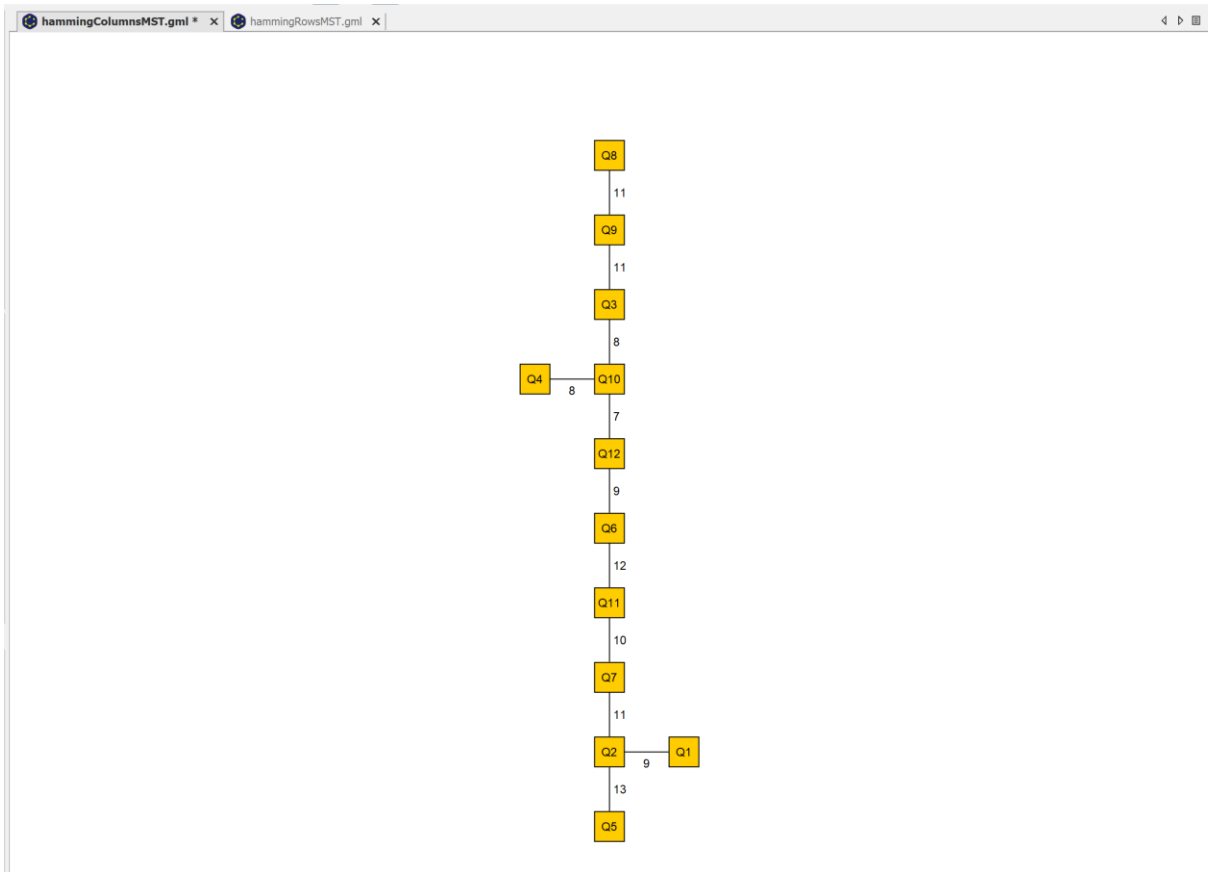
Jaccard distance matrix between columns of US Presidency dataset:

| | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 | Q11 | Q12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Q1 | 0 | 0.391304 | 0.818182 | 0.571429 | 0.733333 | 0.727273 | 0.56 | 0.692308 | 0.73913 | 0.857143 | 0.727273 | 0.863636 |
| Q2 | 0.391304 | 0 | 0.809524 | 0.84 | 0.52 | 0.714286 | 0.478261 | 0.68 | 0.88 | 0.85 | 0.65 | 0.857143 |
| Q3 | 0.818182 | 0.809524 | 0 | 0.714286 | 0.761905 | 0.933333 | 0.736842 | 0.777778 | 0.785714 | 0.8 | 1 | 0.818182 |
| Q4 | 0.571429 | 0.84 | 0.714286 | 0 | 0.888889 | 0.75 | 0.727273 | 0.818182 | 0.6875 | 0.666667 | 0.888889 | 0.866667 |
| Q5 | 0.733333 | 0.52 | 0.761905 | 0.888889 | 0 | 0.833333 | 0.56 | 0.64 | 0.84 | 0.857143 | 0.727273 | 0.809524 |
| Q6 | 0.727273 | 0.714286 | 0.933333 | 0.75 | 0.833333 | 0 | 0.869565 | 0.736842 | 0.8125 | 0.833333 | 0.8 | 0.75 |
| Q7 | 0.56 | 0.478261 | 0.736842 | 0.727273 | 0.56 | 0.869565 | 0 | 0.72 | 0.826087 | 0.9 | 0.555556 | 0.904762 |
| Q8 | 0.692308 | 0.68 | 0.777778 | 0.818182 | 0.64 | 0.736842 | 0.72 | 0 | 0.611111 | 0.947368 | 0.736842 | 0.95 |
| Q9 | 0.73913 | 0.88 | 0.785714 | 0.6875 | 0.84 | 0.8125 | 0.826087 | 0.611111 | 0 | 1 | 0.8125 | 0.857143 |
| Q10 | 0.857143 | 0.85 | 0.8 | 0.666667 | 0.857143 | 0.833333 | 0.9 | 0.947368 | 1 | 0 | 1 | 0.777778 |
| Q11 | 0.727273 | 0.65 | 1 | 0.888889 | 0.727273 | 0.8 | 0.555556 | 0.736842 | 0.8125 | 1 | 0 | 1 |
| Q12 | 0.863636 | 0.857143 | 0.818182 | 0.866667 | 0.809524 | 0.75 | 0.904762 | 0.95 | 0.857143 | 0.777778 | 1 | 0 |

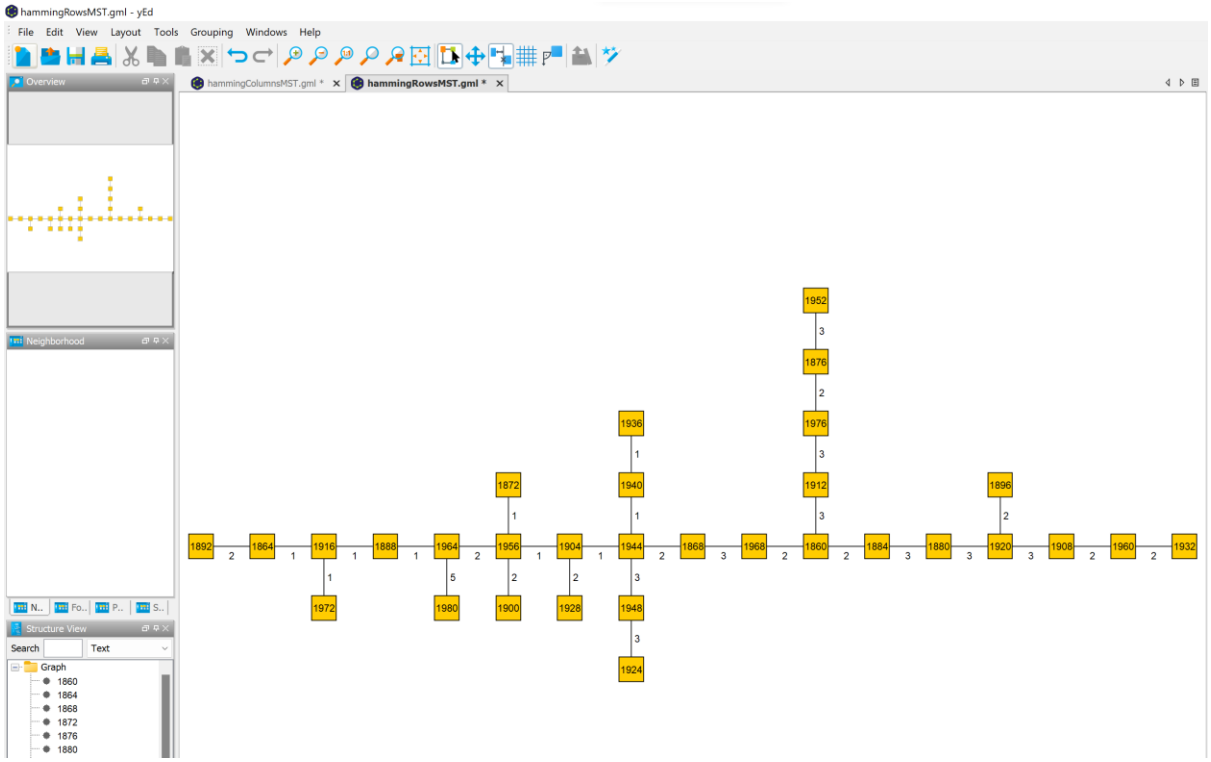
These matrices were produced using the same process as above although when the “hammyDist” and “jaccDist” functions were called in the while loop the arguments were columns (i.e., attributes) of the US presidency dataset instead of rows. The function that returns these matrices is “hamJaccColMatrix”.

**c)**

Minimum spanning tree constructed from Hamming distance matrix between columns of US Presidency dataset:




Minimum spanning tree from Hamming Distance matrix between all pairs of elections of US Presidency dataset:



Function mstGraph returns these graphs. Both Minimum spanning trees were constructed by using the hamming distance matrices for the columns and the rows and using them as an argument in the R function graph_from_adjacency_matrix()  from the igraph package in R;

## Value

An igraph graph object.

## Arguments

| | |
|---|---|
| `adjmatrix` | A square adjacency matrix. From igraph version 0.5.1 this can be a sparse matrix created with the `Matrix` package. |
| `mode` | Character scalar, specifies how igraph should interpret the supplied matrix. See also the `weighted` argument, the interpretation depends on that too. Possible values are: `directed`, `undirected`, `upper`, `lower`, `max`, `min`, `plus`. See details below. |
| `weighted` | This argument specifies whether to create a weighted graph from an adjacency matrix. If it is `NULL` then an unweighted graph is created and the elements of the adjacency matrix gives the number of edges between the vertices. If it is a character constant then for every non-zero matrix entry an edge is created and the value of the entry is added as an edge attribute named by the `weighted` argument. If it is `TRUE` then a weighted graph is created and the name of the edge attribute will be `weight`. See also details below. |
| `diag` | Logical scalar, whether to include the diagonal of the matrix in the calculation. If this is `FALSE` then the diagonal is zerod out first. |
| `add.colnames` | Character scalar, whether to add the column names as vertex attributes. If it is "`NULL`" (the default) then, if present, column names are added as vertex attribute 'name'. If "`NA`" then they will not be added. If a character constant, then it gives the name of the vertex attribute to add. |
| `add.rownames` | Character scalar, whether to add the row names as vertex attributes. Possible values the same as the previous argument. By default row names are not added. If "`add.rownames`" and "`add.colnames`" specify the same vertex attribute, then the former is ignored. |

In this case the arguments occupied were adjmatrix which was hamming distance matrices from questions 1a and 1b, mode which was undirected and weighted which was set equal to true. This led to producing two weighted graphs with the edge attribute ‘weight’ which was used to name the label the edges of the weights on the graph.

The mst function from the igraph package in R was also used with the only argument being the new graph objects created;

## Description

A subgraph of a connected graph is a *minimum spanning tree* if it is tree, and the sum of its edge weights are the minimal among all tree subgraphs of the graph. A minimum spanning forest of a graph is the graph consisting of the minimum spanning trees of its components.

## Usage

```
mst(graph, weights = NULL, algorithm = NULL, ...)
```

## Arguments

| | |
|---|---|
| `graph` | The graph object to analyze. |
| `weights` | Numeric algorithm giving the weights of the edges in the graph. The order is determined by the edge ids. This is ignored if the `unweighted` algorithm is chosen. Edge weights are interpreted as distances. |
| `algorithm` | The algorithm to use for calculation. `unweighted` can be used for unweighted graphs, and `prim` runs Prim's algorithm for weighted graphs. If this is `NULL` then igraph tries to select the algorithm automatically: if the graph has an edge attribute called `weight` or the `weights` argument is not `NULL` then Prim's algorithm is chosen, otherwise the unweighted algorithm is performed. |
| `...` | Additional arguments, unused. |

This produced Minimum spanning trees for the hamming distance matrix between columns and between rows of the US Presidency data set using Prims algorithm since the graph has an edge attribute called weight.

The mst of the graph object was then used as an argument in the function write_graph() from the igraph package;

## Description

`write_graph` is a general function for exporting graphs to foreign file formats, however not many formats are implemented right now.

## Usage

```
write_graph(
  graph,
  file,
  format = c("edgelist", "pajek", "ncol", "lgl", "graphml", "dimacs", "gml", "dot",
    "leda"),
  ...
)
```

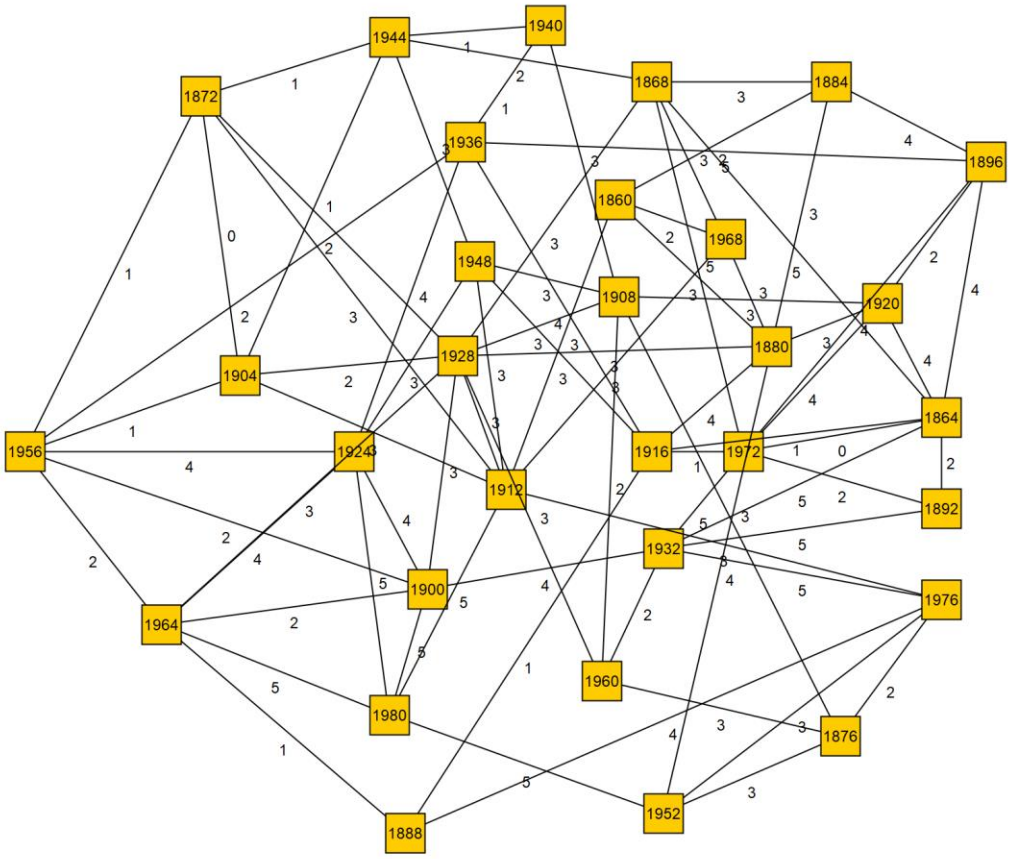
## Arguments

| | |
|---|---|
| `graph` | The graph to export. |
| `file` | A connection or a string giving the file name to write the graph to. |
| `format` | Character string giving the file format. Right now `pajek`, `graphml`, `dot`, `gml`, `edgelist`, `lgl`, `ncol` and `dimacs` are implemented. As of igraph 0.4 this argument is case insensitive. |
| `...` | Other, format specific arguments, see below. |

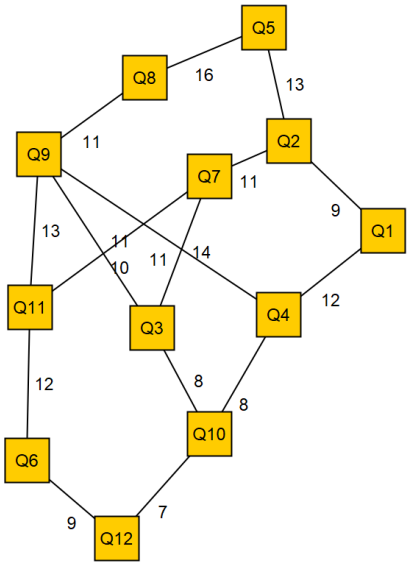
other arguments used were the file name and format which was gml which led to successfully producing the graph in yEd as required.

**Exercise 2)**

Relative Neighbourhood graph for Hamming distance matrix between rows of US presidency dataset:



Relative Neighbourhood graph for Hamming distance matrix between columns of the US Presidency dataset:



The rng() from the package cccd in R was used;

rng {cccd} R Documentation

**Relative Neighborhood Graph.**

## Description

the relative neighborhood graph defined by a set of points.

## Usage

```
rng(x=NULL, dx=NULL, r = 1, method = NULL, usedeldir = TRUE, open = TRUE, k = NA,
    algorithm = 'cover_tree')
```

## Arguments

`x`
: a data matrix. Either `x` or `dx` must be provided.

`dx`
: an interpoint distance matrix.

`r`
: a multiplier to grow the balls.

`method`
: the method used for the distance. See `dist`

`usedeldir`
: a logical. If true and the data are two dimensional and the deldir package is installed, the Delaunay triangularization is first computed, and this is used to compute the relative neighborhood graph.

`open`
: logical. If TRUE, open balls are used in the definition.

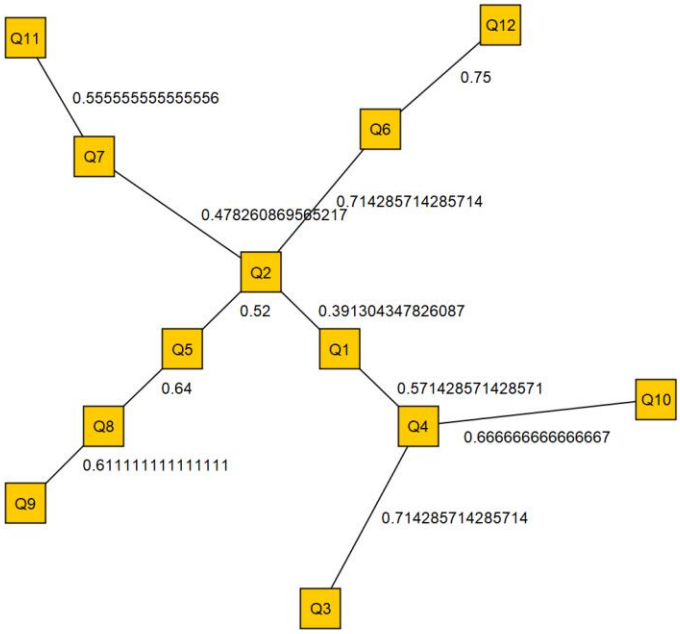
`k`
: If given, `get.knn` is used from FNN to approximate the relative neighborhood graph. Only the `k` nearest neighbors to the points are used to determine whether an edge should be made or not. This will be much faster and use less memory for large data sets, but is an approximation unless `k` is sufficiently large.

`algorithm`
: See `get.knn`.

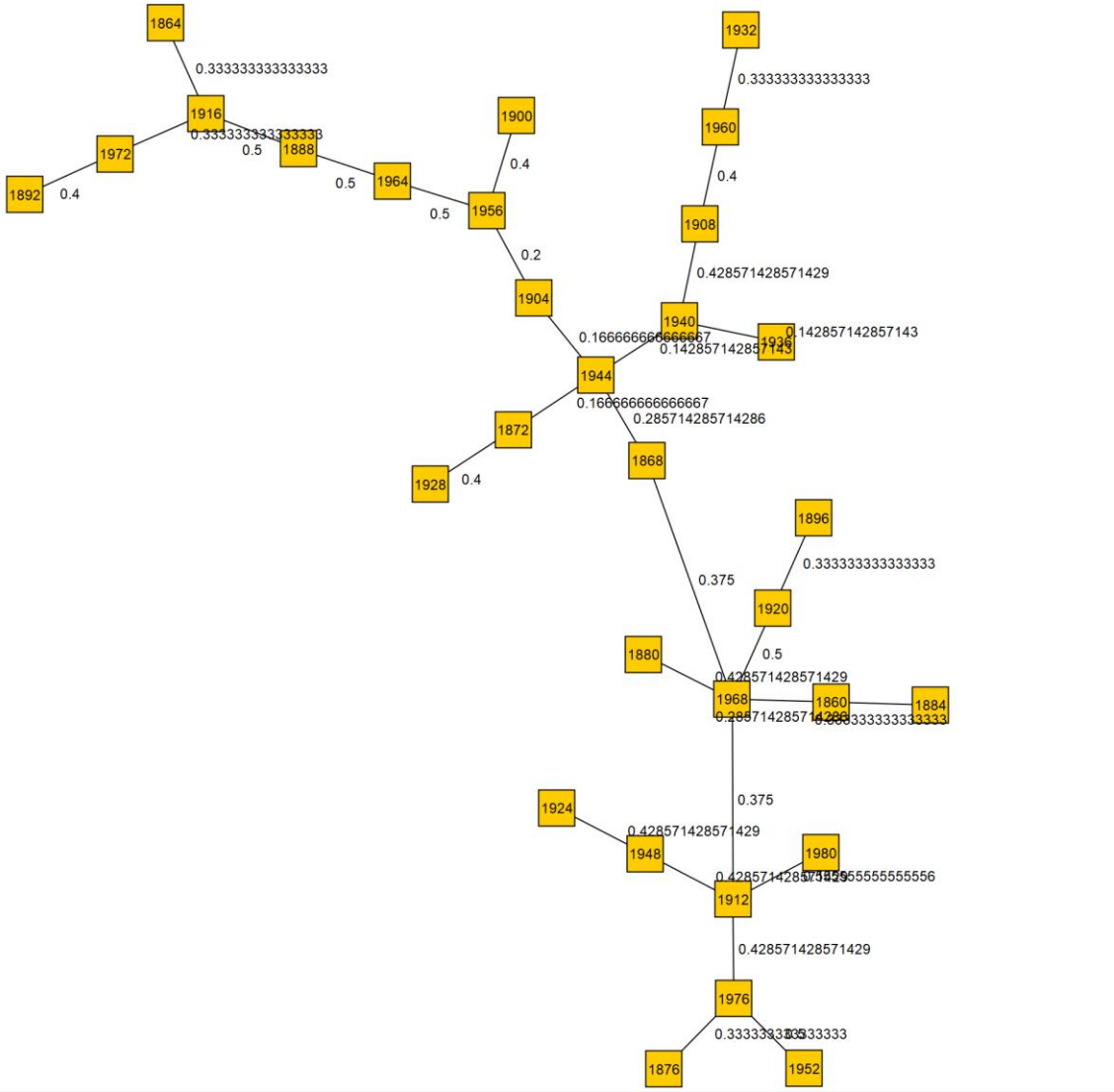
Argument used were the hamming distance matrices from questions 1a and 1b open was set to false r=1 and algorithm = cover_tree. This produces an igraph object. Then using the same process as in 1c with write_graph() the relative neighbourhood graphs for the hamming distance between the rows of the US presidency dataset and the hamming distance matrix between the columns of the US Presidency dataset produced the graphs in yEd as required.

**Exercise 3)**

Minimum spanning tree from Jaccard distance matrix between columns of US Presidency dataset:



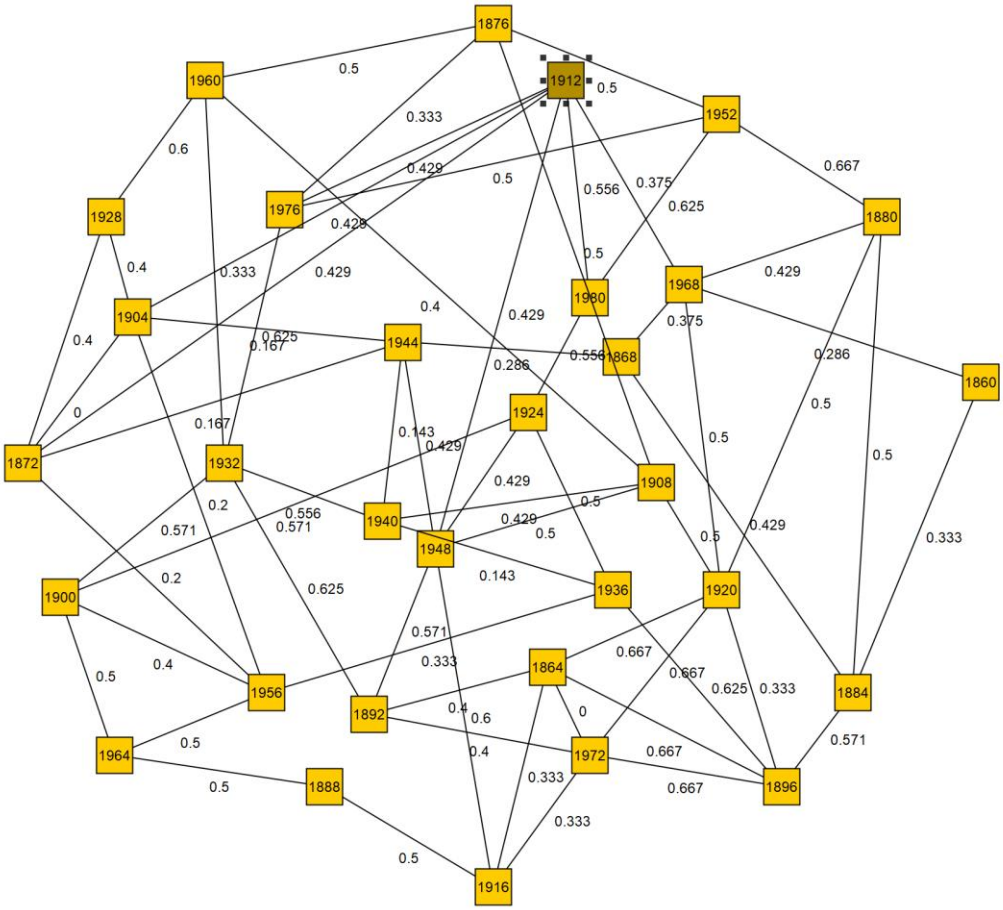
Minimum spanning tree from Jaccard distance matrix between rows of US Presidency dataset:



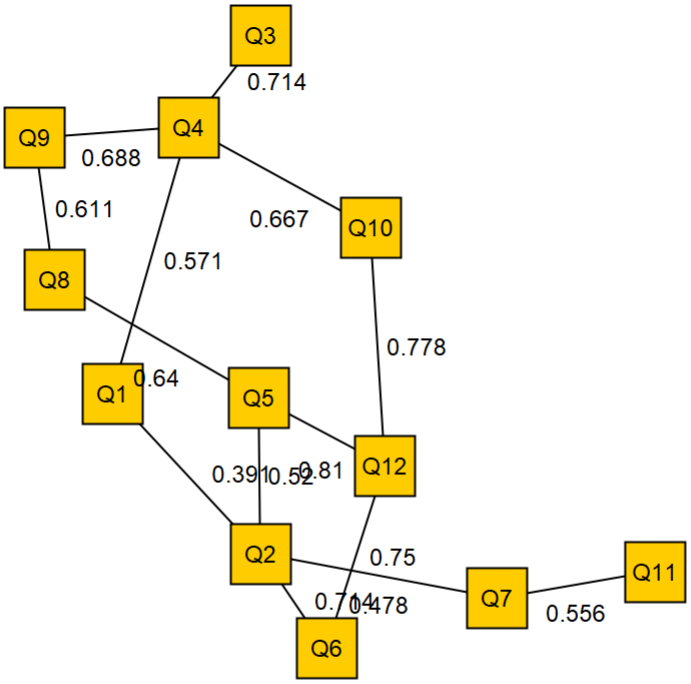

The process used was the same as for q1c except the inputting matrices were the jaccard distance matrices from questions 1a and 1b. The function that returns these graphs is JaccardmstGraph().

**Exercise 4:**

The Relative neighbourhood graph for the jaccard distance matrix between the rows of the US Presidency dataset:



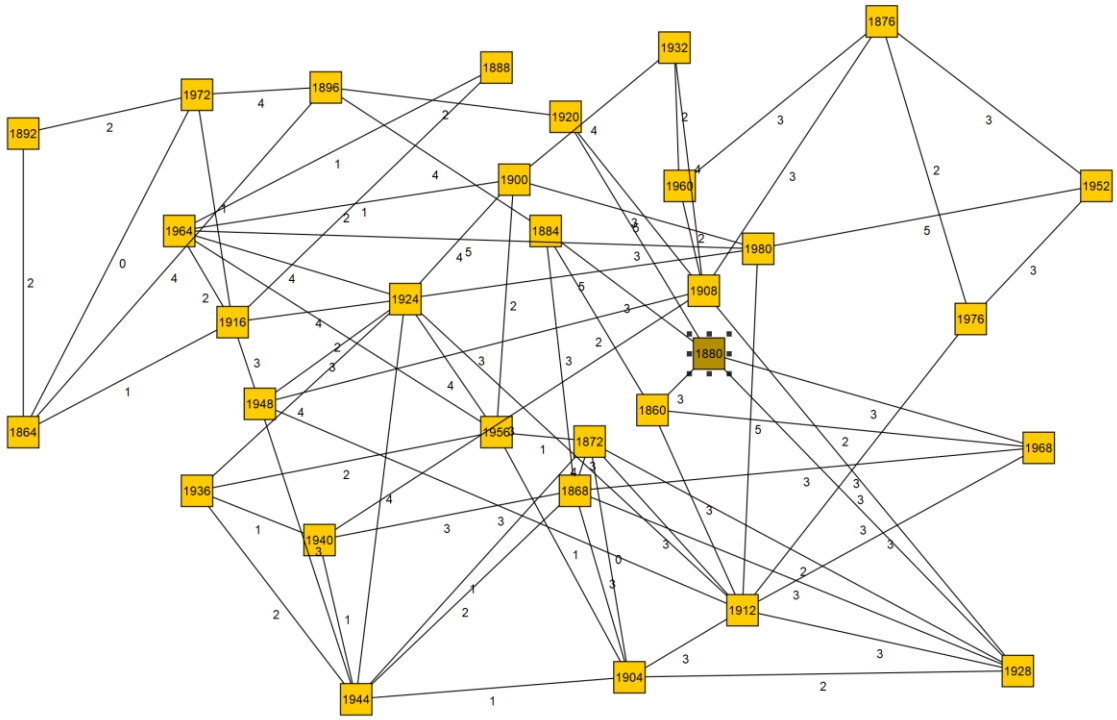

The Relative neighbourhood graph for the Jaccard distance matrix between the columns of the US Presidency dataset:




The same process was used as for exercise 2 except the matrices used are the jaccard distance matrices for the rows and columns of the US Presidency dataset from q1a and q1b. The function that returns these graphs is jaccardRNG().

**Exercise 5)**

The k-NN with k=2 for the Hamming Distance matrix between all pairs of elections of the US Presidency Dataset:


1876
1932
1888
1972
1896
1920
1892
1900
1960
1952
1964
1884
1980
1908
1924
1916
1976
1880
1948
1860
1864
1956
1872
1968
1936
1868
1940
1912
1928
1904
1944

The nng() function from the cccd package is used in order to produce a knn graph;

nng {cccd} R Documentation

## Nearest Neighbor Graphs

### Description

nearest neighbor, k-nearest neighbor, and mutual k-nearest neighbor (di)graphs.

### Usage

```
nng(x = NULL, dx = NULL, k = 1, mutual = FALSE, method = NULL,
    use.fnn = FALSE, algorithm = 'cover_tree')
```

### Arguments

| | |
|---|---|
| x | a data matrix. Either x or dx is required |
| dx | interpoint distance matrix |
| k | number of neighbors |
| mutual | logical. if true the neighbors must be mutual. See details. |
| method | the method used for the distance. See dist |
| use.fnn | logical. If TRUE, get.knn from the FNN package is used to obtain the neighbors. |
| algorithm | see get.knn. |

### Details

a k-nearest neighbor graph is a digraph where each vertex is associated with an observation and there is a directed edge between the vertex and it's k nearest neighbors. A mutual k-nearest neighbor graph is a graph where there is an edge between x and y if x is one of the k nearest neighbors of y AND y is one of the k nearest neighbors of x.

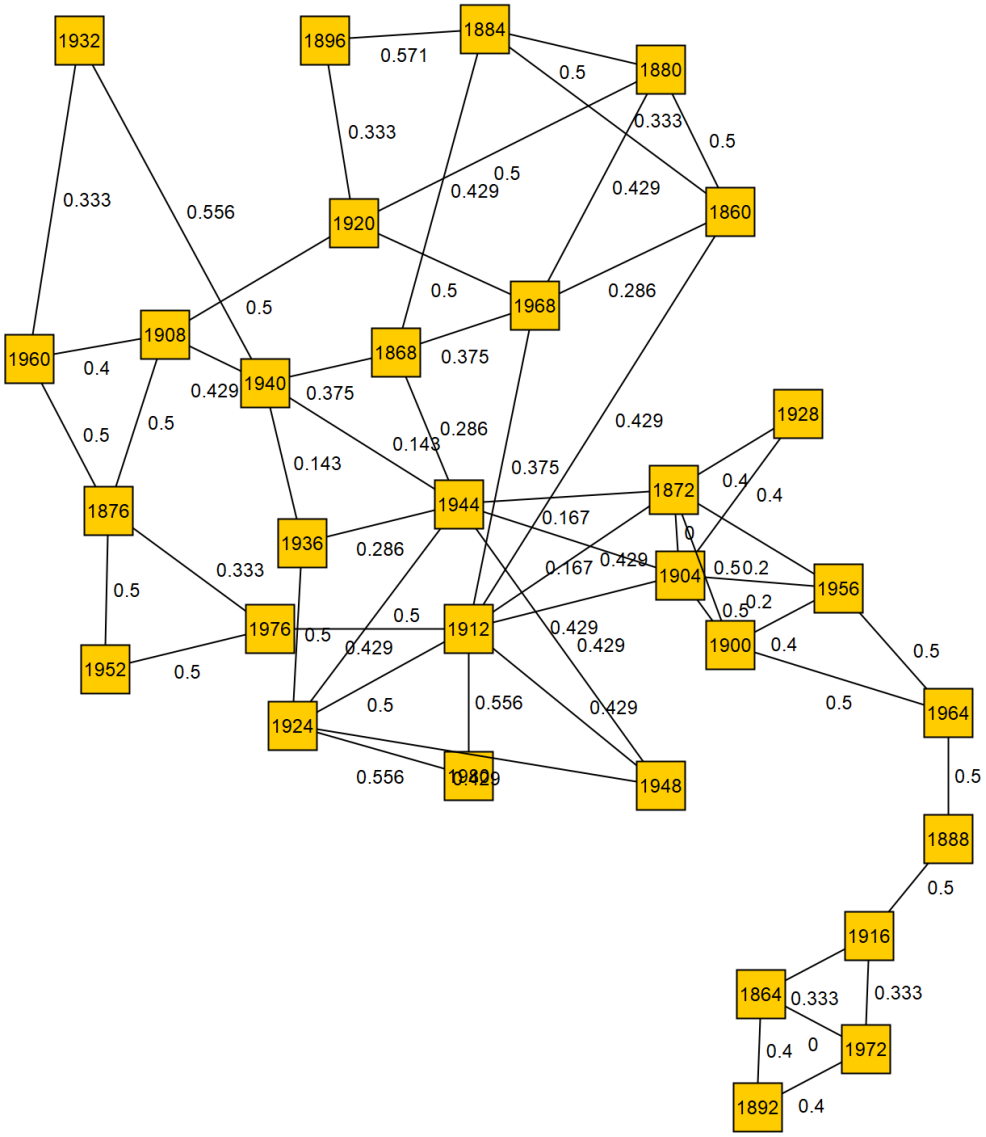
### Value

an object of class igraph with the extra attributes

the argument x is used and is set to the Hamming distance matrix between all pairs of elections of the US Presidency Dataset, k is set to 2 as instructed and the algorithm is set = to cover_tree. The function that returns the knn graph is knnHammingRows()

**Exercise 6:**

The k-NN with k=2 for the Jaccard Distance matrix between all pairs of elections of the US Presidency Dataset:




The process used for exercise 5 was also used for exercise 6 although the matrix used was the Jaccard Distance matrix between all pairs of elections of the US Presidency Dataset from q1a. The function that returns this graph is knnJacRows().

**Exercise 7:**

The intersection function from the igraph package was used in both exercise 7 and 8 it returns the edges that are used in both graphs used as arguments within the function:

---

intersection.igraph {igraph} R Documentation

## Intersection of graphs

### Description

The intersection of two or more graphs are created. The graphs may have identical or overlapping vertex sets.

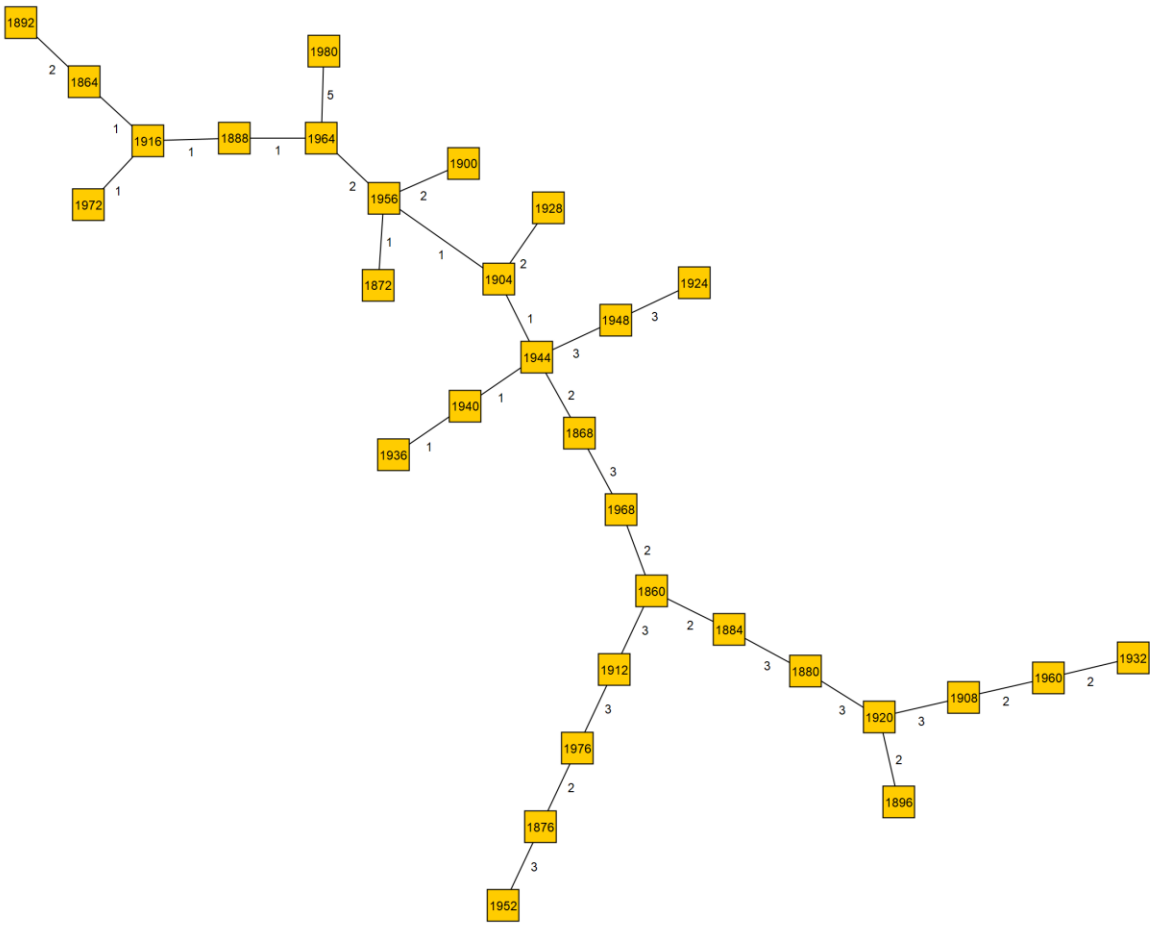
### Usage

```
## S3 method for class 'igraph'
intersection(..., byname = "auto", keep.all.vertices = TRUE)
```

### Arguments

| | |
|---|---|
| `...` | Graph objects or lists of graph objects. |
| `byname` | A logical scalar, or the character scalar `auto`. Whether to perform the operation based on symbolic vertex names. If it is `auto`, that means `TRUE` if all graphs are named and `FALSE` otherwise. A warning is generated if `auto` and some (but not all) graphs are named. |
| `keep.all.vertices` | Logical scalar, whether to keep vertices that only appear in a subset of the input graphs. |

Graph of common edges between the MST for hamming distance between election from question 1c and the knn graph from question 5:

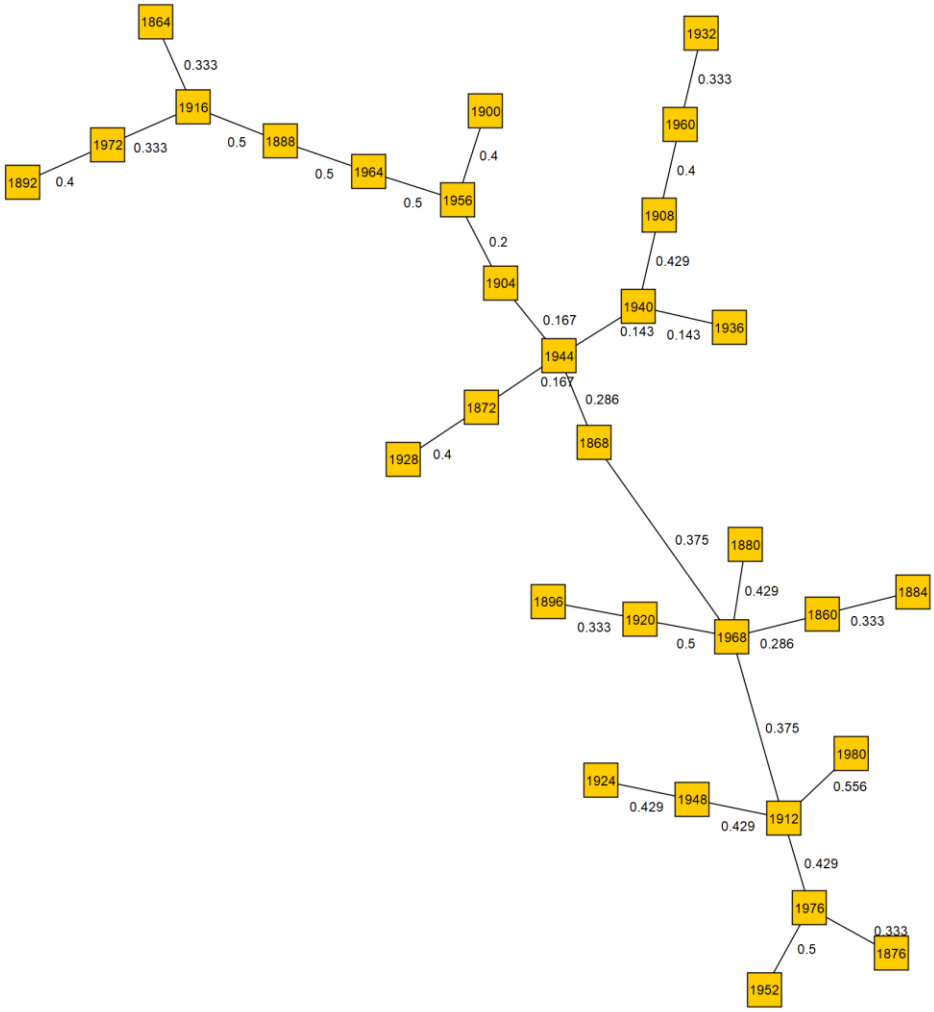



Elections in tabular form grouped by different clusters observed:

| Cluster1 | Cluster2 | Cluster3 | Cluster4 | Cluster5 |
|---|---|---|---|---|
| 1868 | 1900 | 1892 | 1884 | 1936 |
| 1968 | 1956 | 1864 | 1880 | 1940 |
| 1860 | 1872 | 1972 | 1920 | 1944 |
| 1912 | 1928 | 1916 | 1896 | 1948 |
| 1976 | 1904 | 1888 | 1908 | 1924 |
| 1876 | | 1964 | 1960 | |
| 1952 | | 1980 | 1932 | |
| | | | | |

**Exercise 8:**

Graph of common edges between the MST for Jaccard distance between elections from exercise 3 and the knn graph from question 6:



Elections in tabular form grouped by the different clusters observed:

| Cluster1 | Cluster2 | Cluster3 | Cluster4 |
|---|---|---|---|
| 1924 | 1864 | 1932 | 1868 |
| 1948 | 1892 | 1960 | 1896 |
| 1912 | 1972 | 1908 | 1920 |
| 1980 | 1916 | 1940 | 1968 |
| 1976 | 1888 | 1936 | 1880 |
| 1876 | 1964 | 1944 | 1860 |
| 1952 | 1900 | 1872 | 1884 |
| | 1956 | 1928 | |
| | 1904 | | |

# COMP3340A1 Code

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## R Markdown

```
# install.packages('cccd')
 # install.packages('rgexf')
 # install.packages('BNSL')
 # install.packages('igraph')
 # install.packages('XGR')


# Returns the Jaccard similarities between any two binary strings
jaccDist <- function(bin1,bin2){
  #The sum of the pairs of attributes that are both equal to 1; Amount of times both years have 1/true
  inters = sum(bin1 + bin2 == 2)
  #The number of times in which only one of the years value is 1 + the intersection.
  join = sum(bin1 + bin2 == 1) + inters
  1 - (inters/join)
}

# Returns hamming distance between any two binary data strings
hammyDist <- function(binA,binB){

  return(sum(binA != binB))
}


 main <- function()
 {
   library('rgexf')
   library('BNSL')
   library('igraph')
   library('cccd')
   library('class')
   hamJaccRowMatrix()
   hamJaccColMatrix
   mstGraph()
   RNGHamming()
   JaccardmstGraph()
   jaccardRNG()
   knnHammingRows()
   knnJacRows()
   commonEdgeMstKnn()
```

```
  commonEdgesJaccardRows()


}


# Exercise 1)

# a)

# Returns the Hamming distance and jaccard matrices for question 1a
hamJaccRowMatrix <- function(){
  US = read.csv("USPresidency.csv")
  US$Target <- NULL
  # Makes empty base matrix to be used for Question1(a)
  emptyMat <- matrix(nrow = nrow(US), ncol = nrow(US))
  dim(emptyMat)
  #Assigns the Years as the Names of the columns and rows of the Base Matrix.
  colnames(emptyMat) <- US[,1]
  rownames(emptyMat) <- US[,1]
  US$Year <- NULL
  #Deep Copies the empty matrix into the two result matrices.
  hammyMat <- emptyMat
  jaccMat <- emptyMat
  i <- 1
  j <- 1
  # Assigns hamming distance and jaccard distances to new matrices
  while(i < nrow(emptyMat)+1){
    while(j < ncol(emptyMat)+1){
      hammyMat[i,j] <-  hammyDist(US[i,],US[j,])
      jaccMat[i,j] <- jaccDist(US[i,],US[j,])

      j = j + 1
    }
    i = i + 1
    j = 1
  }
  # Jaccard and Hamming comparisons between rows of dataset Matrices stored in list
  hamJaccRowLis <- list(hammyMat,jaccMat)
  hamJaccRowLis
}
hamJaccRowMatrix()


# b)

# Returns the Hamming Distance Matrix and matrix generated by jaccard measure that
# is obtained by comparing columns of dataset
hamJaccColMatrix <- function()
{
  US = read.csv("USPresidency.csv")
  US$Target = NULL
  US$Year <- NULL
```

```
  colMat <- matrix(nrow = ncol(US), ncol = ncol(US))

  colnames(colMat) <- colnames(US)
  rownames(colMat) <- colnames(US)
  hamColMat <- colMat
  jaccColMat <- colMat
  x <- 1
  y <- 1

  # Assigns hamming distance and jaccard distances to new matrices
  while(x < nrow(colMat)+1){
    while(y < ncol(colMat)+1){

      hamColMat[x,y] <-  hammyDist(US[,x],US[,y])
      jaccColMat[x,y] <- jaccDist(US[,x],US[,y])

      y = y + 1
    }
    x = x + 1
    y = 1
  }
  write.csv(hamColMat, "HammingColsDistanceMatrix1.csv")
  write.csv(jaccColMat, "JaccardColsDistanceMatrix1.csv")

  # Jaccard and Hamming Matrices stored in list
  hamJaccColLis <- list(hamColMat,jaccColMat)
  hamJaccColLis

}


# c)

# Returns the Mininum Spanning tree graph for the Hamming distance matrices
# from questions 1a and 1b
mstGraph <- function ()
{

  q1a = hamJaccRowMatrix()
  q1b = hamJaccColMatrix()

  hamRows = q1a[[1]]
  hamCols =q1b[[1]]
  hamRowsGraph <- graph_from_adjacency_matrix(hamRows,mode = 'undirected', weighted = TRUE)
  hamColsGraph <- graph_from_adjacency_matrix(hamCols,mode = 'undirected', weighted = TRUE)

  #Sets the labels and edge weights which will be displayed in yEd
  V(hamRowsGraph)$label <- colnames(hamRows)
  V(hamColsGraph)$label <- colnames(hamCols)
  E(hamRowsGraph)$label <- E(hamRowsGraph)$weight
  E(hamColsGraph)$label <- E(hamColsGraph)$weight

  # writes graph to gml file to be displayed in yEd graph editor
```

```
  write_graph((mst(hamRowsGraph)),'hammingRowsMST.gml',format = "gml")
  write_graph(mst(hamColsGraph),'hammingColumnsMST.gml',format = "gml")
  plot(mst(hamRowsGraph))
  plot(mst(hamColsGraph))

}


# Exercise 2

 # Returns the Relative Neighborhood graphs for the Hamming distance matrices
 # from questions 1a and 1b
 RNGHamming <- function()
 {
   q1a = hamJaccRowMatrix()
   q1b = hamJaccColMatrix()
   hamRows = q1a[[1]]
   hamCols = q1b[[1]]
   rngHamRows <- rng(dx=hamRows, open = FALSE, r = 1, algorithm = 'cover_tree')
   rngHamCols <- rng(dx=hamCols, open = FALSE, r = 1, algorithm = 'cover_tree')

   # sets graphs to undirected
   rngHamRows <- as.undirected(rngHamRows)
   rngHamCols <- as.undirected(rngHamCols)

   #Sets the labels which will be displayed in yEd
   E(rngHamRows)$weight <- apply(get.edges(rngHamRows,1:ecount(rngHamRows)),1,function(x)hamRows[x[1],x
   E(rngHamCols)$weight <- apply(get.edges(rngHamCols,1:ecount(rngHamCols)),1,function(x)hamCols[x[1],x
   E(rngHamRows)$label <- E(rngHamRows)$weight
   E(rngHamCols)$label <- E(rngHamCols)$weight
   V(rngHamRows)$label <- colnames(hamRows)
   V(rngHamCols)$label <- colnames(hamCols)

   # writes graph to gml file to be displayed in yEd graph editor
   write_graph(rngHamRows, 'hammingRowsRNG.gml', format = "gml")
   write_graph(rngHamCols, 'hammingColsRNG.gml', format = "gml")
   plot(rngHamRows)
   plot(rngHamCols)
 }



# Exercise 3

 # Returns the Minimum Spanning tree graph for the Jaccard distance matrices
 # from questions 1a and 1b
 JaccardmstGraph <- function ()
 {

   q1a = hamJaccRowMatrix()
   q1b = hamJaccColMatrix()

   jacRows = q1a[[2]]
```

```
  jacCols =q1b[[2]]
  jacRowsGraph <- graph_from_adjacency_matrix(jacRows,mode = 'undirected', weighted = TRUE)
  jacColsGraph <- graph_from_adjacency_matrix(jacCols,mode = 'undirected', weighted = TRUE)

  #Sets the vertice labels and edge weights which will be displayed in yEd
  V(jacRowsGraph)$label <- colnames(jacRows)
  V(jacColsGraph)$label <- colnames(jacCols)
  E(jacRowsGraph)$label <- E(jacRowsGraph)$weight
  E(jacColsGraph)$label <- E(jacColsGraph)$weight

  # writes graph to gml file to be displayed in yEd graph editor
  write_graph((mst(jacRowsGraph)),'jaccardRowsMST.gml',format = "gml")
  write_graph(mst(jacColsGraph),'jaccardColumnsMST.gml',format = "gml")

  plot(mst(jacRowsGraph))
  plot(mst(jacColsGraph))

}



# Exercise 4

 # Returns the Relative Neighborhood Graph for the Jaccard distance matrices
 # from questions 1a and 1b
jaccardRNG <- function()
{
  q1a = hamJaccRowMatrix()
  q1b = hamJaccColMatrix()
  jacRows = q1a[[2]]
  jacCols = q1b[[2]]
  rngJacRows <- rng(dx=jacRows, r = 1, open = FALSE, algorithm = 'cover_tree')
  rngJacCols <- rng(dx=jacCols, r = 1, open = FALSE, algorithm = 'cover_tree')

  # sets graphs to undirected
  rngjacRows <- as.undirected(rngJacRows)
  rngJacCols <- as.undirected(rngJacCols)

  #Sets the vertice labels which will be displayed on the graph in yEd
  E(rngJacRows)$weight <- apply(get.edges(rngJacRows,1:ecount(rngJacRows)),1,function(x)jacRows[x[1],x
  E(rngJacCols)$weight <- apply(get.edges(rngJacCols,1:ecount(rngJacCols)),1,function(x)jacCols[x[1],x
  E(rngJacRows)$label <- round(E(rngJacRows)$weight, 3)
  E(rngJacCols)$label <- round(E(rngJacCols)$weight, 3)
  V(rngJacRows)$label <- colnames(jacRows)
  V(rngJacCols)$label <- colnames(jacCols)

  # writes graph to gml file to be displayed in yEd graph editor
  write_graph(rngJacRows, 'jaccardRowsRNG.gml', format = "gml")
  write_graph(rngJacCols, 'jaccardColsRNG.gml', format = "gml")
  plot(rngJacRows)
  plot(rngJacCols)
}
```

```r
# Exercise 5
 # Returns the knn graph with k=2 for the Hamming distance matrix between all pairs
 # of elections of the US Presidency Dataset
 knnHammingRows <- function(){
 q1a <- hamJaccRowMatrix()
 hammyRows <- q1a[[1]]
 knnGraphHam <- nng(dx = hammyRows, k = 2, algorithm = 'cover_tree')
 # sets graph to an undirected graph
 knnGraphHam <- as.undirected(knnGraphHam)

 # sets edge and vertice lables to be used in yEd graph editor
 E(knnGraphHam)$weight <- apply(get.edges(knnGraphHam,1:ecount(knnGraphHam)),1,function(x)hammyRows[x[1]
 E(knnGraphHam)$label <- E(knnGraphHam)$weight
 V(knnGraphHam)$label <- colnames(hammyRows)

 # writes graph to gml file to be displayed in yEd graph editor
 write_graph(knnGraphHam, 'hammingRowsKnn.gml', format = "gml")
 plot(knnGraphHam)
 }



# Exercise 6
 # Returns the knn graph with k=2 for the Jaccard distance matrix between all pairs
 # of elections of the US Presidency Dataset
 knnJacRows <- function(){
   q1a <- hamJaccRowMatrix()
   jacRows <- q1a[[2]]
   knnGraphJac <- nng(dx = jacRows, k = 2, algorithm = 'cover_tree')

   # set to undirected graph
   knnGraphJac <- as.undirected(knnGraphJac)

   # writes graph to gml file to be displayed in yEd graph editor
   E(knnGraphJac)$weight <- apply(get.edges(knnGraphJac,1:ecount(knnGraphJac)),1,function(x)jacRows[x[1]
   E(knnGraphJac)$label <- round(E(knnGraphJac)$weight, 3)
   V(knnGraphJac)$label <- colnames(jacRows)

   # writes graph to gml file to be displayed in yEd graph editor
   write_graph(knnGraphJac, 'jaccardRowsKnn.gml', format = "gml")
   plot(knnGraphJac)
 }



# Exercise 7
```

```
# Returns graph with common edges from q1c(mst) and q5(knn)
 commonEdgeMstKnn <- function()
 {
   q1a <- hamJaccRowMatrix()
   hammyRows <- q1a[[1]]
   #knn code
   knnGraphHam <- nng(dx = hammyRows, k = 2, algorithm = 'cover_tree')
   knnGraphHam <- as.undirected(knnGraphHam)
   V(knnGraphHam)$name <- colnames(hammyRows)
   V(knnGraphHam)$label <- colnames(hammyRows)

   #mst code
   hamRowsGraph <- graph_from_adjacency_matrix(hammyRows,mode = 'undirected', weighted = TRUE)
   V(hamRowsGraph)$name <- colnames(hammyRows)
   V(hamRowsGraph)$label <- colnames(hammyRows)
   E(hamRowsGraph)$label <- E(hamRowsGraph)$weight
   E(hamRowsGraph)$name <- E(hamRowsGraph)$weight
   hamRowsGraphMST <- mst(hamRowsGraph)

   # stores common edges between graphs in new variable
   commonEdges <- intersection(knnGraphHam, hamRowsGraphMST, byname = "auto" )
   E(commonEdges)$weight <- apply(get.edges(commonEdges,1:ecount(commonEdges)),1,function(x)hammyRows[x
   E(commonEdges)$label <- E(commonEdges)$weight
   V(commonEdges)$name <- colnames(hammyRows)
   V(commonEdges)$label <- colnames(hammyRows)

   write_graph(commonEdges, 'commonEdgeMstKnn_EX7.gml', format = "gml")
   plot(commonEdges)
 }




 # Exercise 8
 commonEdgesJaccardRows <- function()
   {
   q1a <- hamJaccRowMatrix()
   jacRows <- q1a[[2]]

   # knn graph retrieval
   knnGraphJac <- nng(dx = jacRows, k = 2, algorithm = 'cover_tree')
   # set to undirected graph
   knnGraphJac <- as.undirected(knnGraphJac)
   V(knnGraphJac)$label <- colnames(jacRows)
   V(knnGraphJac)$name <- colnames(jacRows)

   # mst graph retrieval
   jacRowsGraph <- graph_from_adjacency_matrix(jacRows,mode = 'undirected', weighted = TRUE)
   #Sets the vertices labels and edge weights which will be displayed in yEd
   V(jacRowsGraph)$label <- colnames(jacRows)
   V(jacRowsGraph)$name <- colnames(jacRows)
   E(jacRowsGraph)$label <- round(E(jacRowsGraph)$weight, 3)
```

```
E(jacRowsGraph)$name <- round(E(jacRowsGraph)$weight, 3)
jacRowsGraphMst <- mst(jacRowsGraph)

# stores common edges between two graphs in new variable
commonEdges <- intersection(knnGraphJac, jacRowsGraphMst, byname = "auto" )
E(commonEdges)$weight <- apply(get.edges(commonEdges,1:ecount(commonEdges)),1,function(x)jacRows[x[1]
E(commonEdges)$label <- round(E(commonEdges)$weight, 3)
V(commonEdges)$name <- colnames(hammyRows)
V(commonEdges)$label <- colnames(hammyRows)
write_graph(commonEdges, 'commonEdgeMstKnn_EX8.gml', format = "gml")
plot(commonEdges)

}
```