Algorithm project

This project includes two tasks related to the sorting and graph algorithms. The goal of the project is to modify and re-implement the Kruskal's algorithm in more efficient way if we assume that the edge weights in the input graphs are integer numbers in the range 0 to j, for some integer j <= n where n is the number of edges. In addition, you need to compare the time complexity of Kruskal's algorithm before and after the modification. Note: based on the above assumption, apply only one modification on the Kruskal's algorithm presented in the lecture.

Part 1:

Kruskal’s before:

```
        Kruskal(G):
                for each vertex:
                        makeSet(v)
        sort each edge in non decreasing order by weight using merge sort #O(ElogE)
        for each edge (u,v):
                if findSet(u)  != findSet(v) :
                MST = MST + edge(u,v)
                union(u,v)
```

analysis:

Line 2-3: makeSet() is V
Line 4: sort the edges is O(ElogE)
Line 5: for loop is O(E)
Line 6-8: find and union is O(log V)

there for complexity is O(ElogE + ElogV)
So, complexity will be O(ElogE) or O(ElogV)

Kruskal’s after:

```
        Kruskal(G):
                for each vertex:
                        makeSet(v)
        sort each edge in non decreasing order by weight using counting sort  #O(E)
        for each edge (u,v):
                if findSet(u)  != findSet(v) :
                MST = MST + edge(u,v)
                union(u,v)
```

analysis:

Line 2-3: makeSet() is V
Line 4: sort the edges is O(E)

Line 5: for loop is O(E)
Line 6-8: find and union is O(log V)

there for complexity is O(E + ElogV)
So, complexity will be O(ElogV) more efficient then O(ElogE)

Algorithms:
makeSet(x){creates a new set whose only members is x}
Union(x,y){units the set containing x with the set containing y}
findSet(x){returns a pointer to set containing x}

Part 2:

Kruskal before:

```
def kruskal_merge(self):
    i,e = 0,0
    ds = dis.disjointset(self.nodes)
    self.graph = merge.merge_sort(self.graph)
    while e<self.V-1:
        w,d,s = self.graph[i]
        i+=1
        x = ds.find(s)
        y= ds.find(d)
        if x!= y:
            e += 1
            self.MST.append([w,d,s])
            ds.union(x,y)
    self.display(s,d,w)
```

Kruskal after:

```
def kruskal_counting(self):
    i,e = 0,0
    ds = dis.disjointset(self.nodes)
    self.graph = counting.counting_sort(self.graph)
    while e<self.V-1:
        w,d,s = self.graph[i]
        i+=1
        x = ds.find(s)
        y= ds.find(d)
        if x!= y:
            e += 1
            self.MST.append([w,d,s])
            ds.union(x,y)
    self.display(s,d,w)
```

Table A:

For each algorithm (Kruskal_before and Kruskal_after) and each size (50, 100, 150, and 200) of the edges, provide the average running time performed by the algorithm.

Algorithm	E=50 (seconds)	E=100 (seconds)	E=150 (seconds)	E=200 (seconds)	E=1000 (seconds)
Kruskal before	0.00380857785542806	0.004401286443074544	0.00585635503133138	0.006313800811767578	0.05584565798441569
Kruskal after	0.0032939910888671875	0.0042527516682942705	0.005573272705078125	0.00538333257039388	0.05498147010803223

Table B:

For each algorithm (Kruskal_before and Kruskal_after) and each size (50, 100, 150, and 200) of the edges, provide the best case of the algorithm (case where the minimum running time by the algorithm is reached).

Algorithm	E=50	E=100	E=150	E=200	E=1000

	(seconds)	(seconds)	(seconds)	(seconds)	(seconds)
Kruskal before	0.0034728050231933594	0.0040628910064697266	0.0054569244384765625	0.005738019943237305	0.05502629280090332
Kruskal after	0.002917051315307617	0.0039010047912597656	0.005280971527099609	0.005159854888916016	0.054368019104003906

Table C:

For each algorithm (Kruskal_before and Kruskal_after) and each size (50, 100, 150, and 200) of the edges, provide the worst case of the algorithm (case where the maximum running time by the algorithm is reached).

Algorithm	E=50 (seconds)	E=100 (seconds)	E=150 (seconds)	E=200 (seconds)	E=1000 (seconds)
Kruskal before	0.0039968490600585940	0.004923105239868164	0.006061077117919922	0.00694727897644043	0.05699801445007324
Kruskal after	0.003728151321411133	0.0048902034759521484	0.005903005599975586	0.005815029144287109	0.05565905570983887

Results analysis:

Table A:

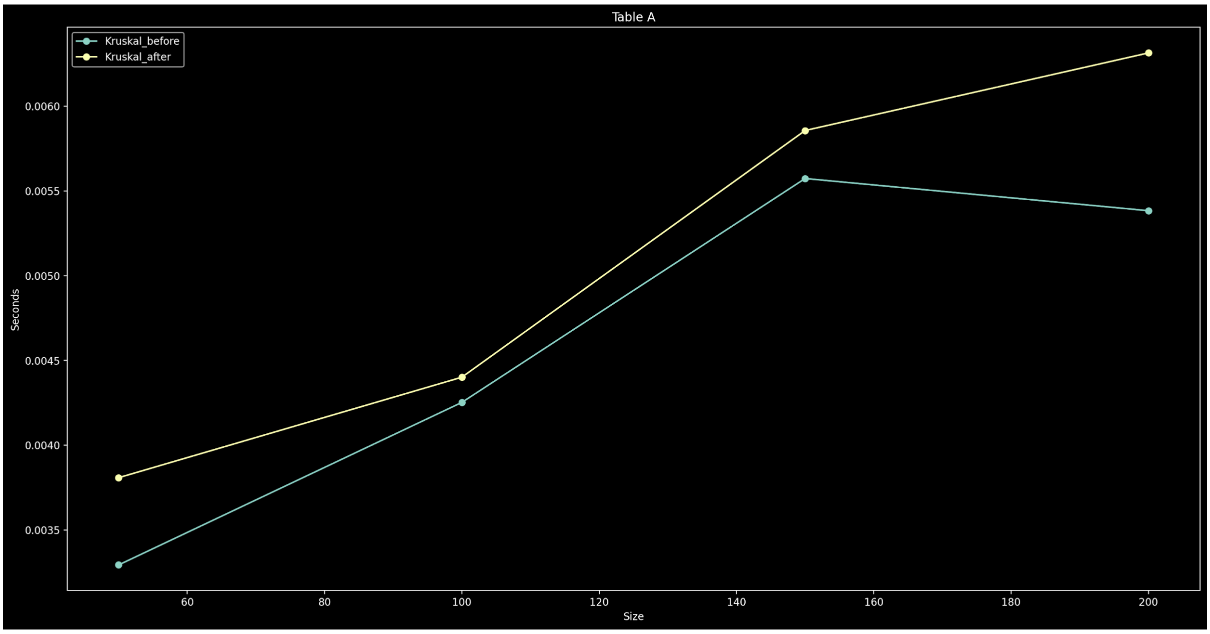


Table B:

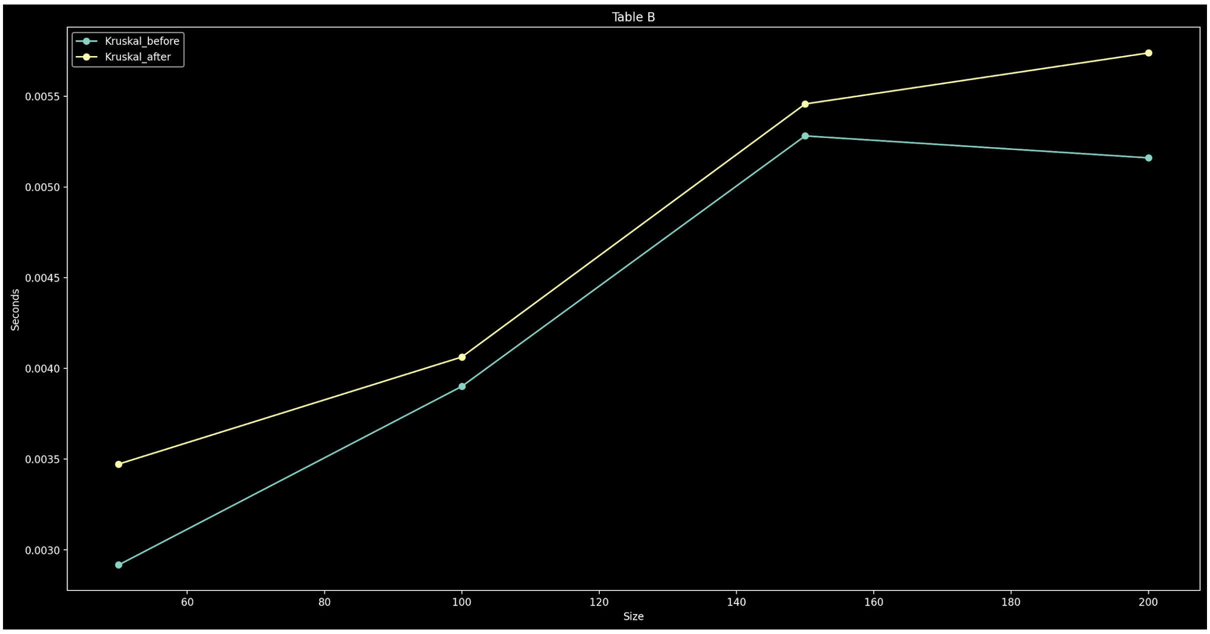
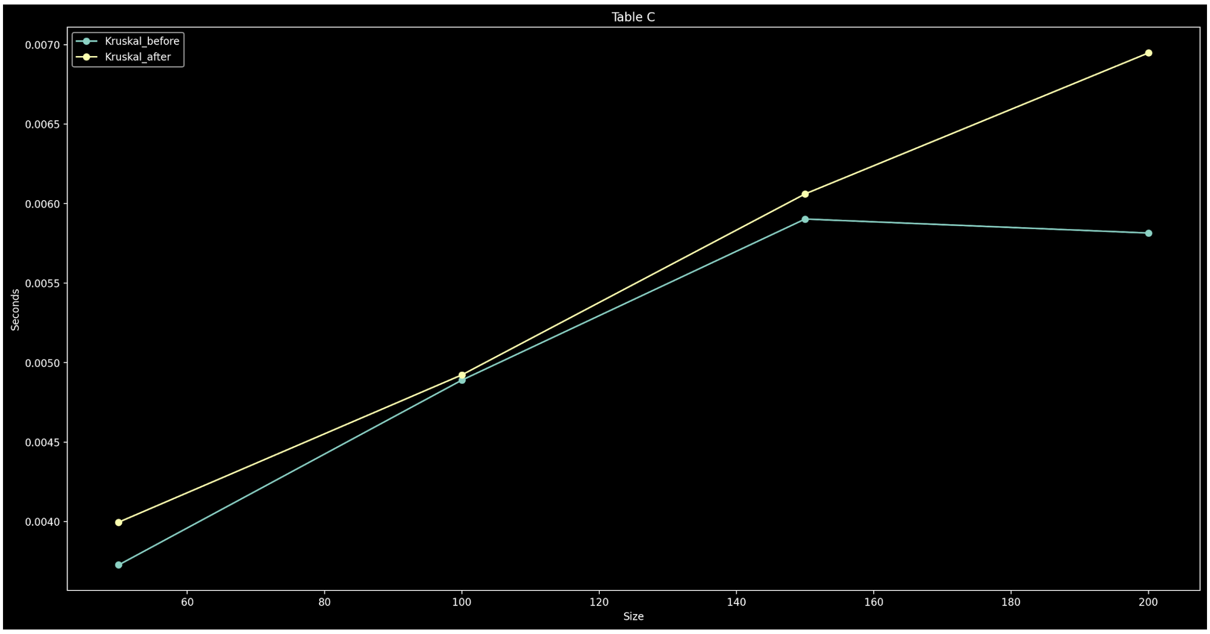


Table C:



Overall:

As we can see from the Big-O in the theoretical section and the results of the algorithm's testing, storing the data in tables, and analyzing them there to find the improved Kruskal is more efficient