Study of the operation of algorithms (Kruskal algorithm, Floyd-Warshall algorithm)

Import needed libraries

```
import random
import networkx as nx
import matplotlib.pyplot as plt
from itertools import combinations, groupby
import time
from tqdm import tqdm
import math
from typing import List, Tuple
```

Graph generation function

```
# You can use this function to generate a random graph with
'num_of_nodes' nodes
# and 'completeness' probability of an edge between any two nodes
# If 'directed' is True, the graph will be directed
# If 'draw' is True, the graph will be drawn
def gnp_random_connected_graph(num_of_nodes: int,
                               completeness: int,
                               directed: bool = False,
                               draw: bool = False):
    """
    Generates a random graph, similarly to an Erdős-Rényi
    graph, but enforcing that the resulting graph is conneted (in case
of undirected graphs)
    """
    if directed:
        G = nx.DiGraph()
    else:
        G = nx.Graph()
    edges = combinations(range(num_of_nodes), 2)
    G.add_nodes_from(range(num_of_nodes))

    for _, node_edges in groupby(edges, key = lambda x: x[0]):
        node_edges = list(node_edges)
        random_edge = random.choice(node_edges)
        if random.random() < 0.5:
            random_edge = random_edge[::-1]
        G.add_edge(*random_edge)
        for e in node_edges:
            if random.random() < completeness:
                G.add_edge(*e)

    for (u,v,w) in G.edges(data=True):
        w['weight'] = random.randint(-5, 20)

    if draw:
        plt.figure(figsize=(10,6))
        if directed:
            # draw with edge weights
            pos = nx.arf_layout(G)
            nx.draw(G,pos, node_color='lightblue',
                    with_labels=True,
                    node_size=500,
                    arrowsize=20,
                    arrows=True)
            labels = nx.get_edge_attributes(G,'weight')
            nx.draw_networkx_edge_labels(G, pos,edge_labels=labels)

        else:
            nx.draw(G, node_color='lightblue',
                with_labels=True,
                node_size=500)
    return G
```

Kruskal algorithm

Task: write a function that will implement Kruskal's algorithm taking as an argument a graph generated using the module provided in the task (function gnp_random_connected_graph). Then compare developed algorithm with native one from imported library

```
#generate random graph
G_kruskal = gnp_random_connected_graph(10, 1, False, False)

def kruskals_algorithm(graph_edges):
    """
    Kruskal's algorithm impemetation
    """
    sorted_graph = sorted(graph_edges, key= lambda x:
x[2].get('weight'))
    connected_nodes_groups = {}
    already_connected_nodes = []
    min_frame = []
    for edge in sorted_graph:
        if not edge[0] in already_connected_nodes or not edge[1] in
already_connected_nodes: # checking if one of the nodes are not
connected
            if not edge[0] in already_connected_nodes and not edge[1]
in already_connected_nodes: # checking for both
                connected_nodes_groups[edge[0]] = [edge[0], edge[1]] #
connect two nodes with each other
```

```
                connected_nodes_groups[edge[1]] = [edge[0], edge[1]]
            else:
                if not connected_nodes_groups.get(edge[0]):
                    connected_nodes_groups[edge[1]].append(edge[0])
                    connected_nodes_groups[edge[0]] =
connected_nodes_groups[edge[1]]
                else:
                    connected_nodes_groups[edge[0]].append(edge[1])
                    connected_nodes_groups[edge[1]] =
connected_nodes_groups[edge[0]]
            min_frame.append(edge)
            already_connected_nodes.append(edge[0])
            already_connected_nodes.append(edge[1])
    for i in sorted_graph:
        if i[0] in connected_nodes_groups[i[0]] and i[1] not in
connected_nodes_groups[i[0]]:
            min_frame.append(i)
    return min_frame
```

Here you can see an example of using created Kruskal algorithm. Function returns List[List[int]] (matrix). Full algorithm is implemented in kruskal_algorithm() function. It takes one argument - List[Tuple[int, int, dict]] (graph edges list with information about weight as a dict). Function returns List[Tuple[int, int, dict]] - minimum carcass for input graph

```
kruskals_algorithm(list(G_kruskal.edges(data=True)))
```

```
[(5, 8, {'weight': -5}),
 (7, 8, {'weight': -5}),
 (2, 8, {'weight': -4}),
 (4, 9, {'weight': -4}),
 (0, 4, {'weight': -3}),
 (3, 6, {'weight': -2}),
 (1, 7, {'weight': -1}),
 (0, 8, {'weight': -2}),
 (6, 9, {'weight': -2}),
 (5, 9, {'weight': -1}),
 (1, 3, {'weight': 1}),
 (4, 7, {'weight': 1}),
 (0, 5, {'weight': 2}),
 (3, 8, {'weight': 2}),
 (0, 6, {'weight': 3}),
 (3, 7, {'weight': 4}),
 (4, 6, {'weight': 4}),
 (5, 6, {'weight': 4}),
 (6, 8, {'weight': 4}),
 (7, 9, {'weight': 4}),
 (3, 5, {'weight': 6}),
 (8, 9, {'weight': 6}),
 (6, 7, {'weight': 7}),
 (1, 4, {'weight': 8}),
 (4, 5, {'weight': 8}),
 (4, 8, {'weight': 9}),
 (0, 3, {'weight': 10}),
 (0, 1, {'weight': 12}),
 (1, 6, {'weight': 13}),
 (0, 2, {'weight': 14}),
 (2, 3, {'weight': 15}),
 (3, 4, {'weight': 15}),
 (1, 9, {'weight': 17}),
 (2, 6, {'weight': 18}),
 (2, 4, {'weight': 18}),
 (0, 7, {'weight': 19}),
 (3, 9, {'weight': 19}),
 (5, 7, {'weight': 19}),
 (2, 9, {'weight': 20})]
```

Kruskal algrorithm time measuring

```
from networkx.algorithms import tree
nodes_kruskal = [10, 20, 50, 100, 200]
NUM_OF_ITERATIONS = 1000

time_taken_imported = 0
kruskal_native_algorithm = []
#For imported kruskal algorithm for 10, 20, 50, 100 and 200 nodes
graph
for node in nodes_kruskal:
    for i in tqdm(range(NUM_OF_ITERATIONS)):
        graph_for_imported = gnp_random_connected_graph(node, 0.4,
False)

        #measure time while algorithm is working
        start = time.time() #start
        tree.minimum_spanning_tree(graph_for_imported,
algorithm="kruskal") #algorithm is working
        end = time.time() #end
        time_taken_imported += end - start
    kruskal_native_algorithm.append(time_taken_imported)
    time_taken_imported / NUM_OF_ITERATIONS
```

```
100%|██████████| 1000/1000 [00:00<00:00, 2052.22it/s]
100%|██████████| 1000/1000 [00:00<00:00, 1026.31it/s]
100%|██████████| 1000/1000 [00:05<00:00, 185.72it/s]
100%|██████████| 1000/1000 [00:17<00:00, 55.65it/s]
100%|██████████| 1000/1000 [01:09<00:00, 14.30it/s]
```

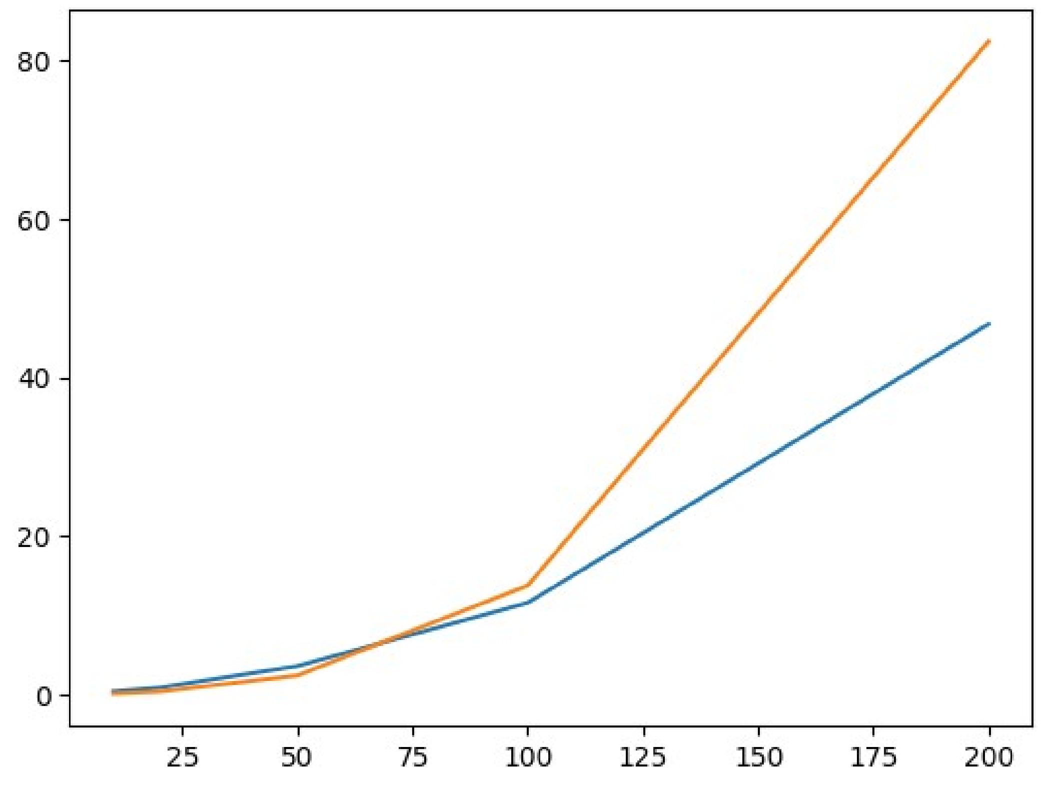
```
time_taken_created = 0
kruskal_own_algorithm = []
#For created kruskal algorithm for 10, 20, 50, 100 and 200 nodes graph
for node in nodes_kruskal:
    for i in tqdm(range(NUM_OF_ITERATIONS)):
        geaph_for_created = gnp_random_connected_graph(node, 0.4,
False)
```

```
        #measure time while algorithm is working
        start = time.time() #start
        kruskals_algorithm(geaph_for_created.edges(data=True))
#algorithm is working
        end = time.time() #end
        time_taken_created += end - start
    kruskal_own_algorithm.append(time_taken_created)
    time_taken_created / NUM_OF_ITERATIONS

100%|██████████| 1000/1000 [00:00<00:00, 3224.02it/s]
100%|██████████| 1000/1000 [00:00<00:00, 1282.23it/s]
100%|██████████| 1000/1000 [00:04<00:00, 218.55it/s]
100%|██████████| 1000/1000 [00:21<00:00, 47.23it/s]
100%|██████████| 1000/1000 [01:40<00:00,  9.93it/s]
```

Here you can see comparing native and created algorithms and a graph that shows diference in time

```
#comparing own and native kruskal algorithms by plotting
plt.plot(nodes_kruskal, kruskal_native_algorithm)
plt.plot(nodes_kruskal, kruskal_own_algorithm)
plt.show()
```



As we see, created algorithm is a little faster than native when graph nodex < 100 and slower than native when nodex > 100. This is because the native algorithm is optimally written by professionals

Floyd-Warshall Algorithm

Task: write a function that will implement Floyd-Warshall's algorithm taking as an argument a graph generated using the module provided in the task (function gnp_random_connected_graph). Then compare developed algorithm with native one from imported library

```
G_floyd = gnp_random_connected_graph(7, 0.001, False, False)
G_floyd.edges(data=True)
```

```
EdgeDataView([(0, 1, {'weight': -2}), (1, 2, {'weight': 3}), (2, 5,
{'weight': 1}), (3, 5, {'weight': 12}), (4, 6, {'weight': -5}), (5, 6,
{'weight': 4})])
```

```
def create_table_for_floyd(graph, is_graph_directed):
    """
    Function that creates table for
    floyd algorithm using generated
    graph
    """
    N = len(graph.nodes)
    table = [[math.inf for _ in range(N)] for _ in range(N)]
    for x, y, w_dict in list(graph.edges(data=True)):
        table[x][x] = 0
        table[y][y] = 0
        if is_graph_directed:
            table[x][y] = w_dict['weight']
        else:
            table[x][y] = w_dict['weight']
            table[y][x] = w_dict['weight']
    return table

def floydworshal_algorithm(graph, is_graph_directed, table = None):
    """
    Floyd-Warshall algorithm implementation

    Args:
        graph: format from generation function - graph
        nodes: int - the sum of nodes
        is_graph_directred: bool - is graph directed?
    Returns:
    """
    if table == None:
        table = create_table_for_floyd(graph, is_graph_directed)
    N = len(graph.nodes)
    for k in range(N):
        for i in range(N):
            for j in range(N):
                d = table[i][k] + table[k][j]
                if i == j and d < 0:
                    return "Negative cycle detected!"
                if table[i][j] > d:
                    table[i][j] = d
    return table
```

Here you can see an example of using created Floyd-Warshall algorithm. Function returns List[List[int]] (matrix). Firstly function create_table_for_floyd() creates the table for algorithm using generated graph and then function floydworshall_algorithm() implements algorithm

```
floydworshal_algorithm(G_floyd, False)
```

```
'Negative cycle detected!'
```

FLoyd-Warshall algrorithm time measuring

```
from networkx.algorithms import
floyd_warshall_predecessor_and_distance
nodes_for_floyd = [10, 20, 50]
NUM_OF_ITERATIONS = 1000

time_taken_imported = 0
floyd_native_algorithm = []
#For imported kruskal algorithm for 10, 20, 50 nodes graph
for node in nodes_for_floyd:
    for i in tqdm(range(NUM_OF_ITERATIONS)):
        graph_for_imported = gnp_random_connected_graph(node, 0.01,
False)

        #measure time while algorithm is working
        start = time.time() #start
        try:
            pred, dist =
floyd_warshall_predecessor_and_distance(graph_for_imported) #algorithm
is working
        except:
            pass
        end = time.time() #end
        time_taken_imported += end - start
    floyd_native_algorithm.append(time_taken_imported)
    time_taken_imported / NUM_OF_ITERATIONS
```

```
100%|██████████| 1000/1000 [00:00<00:00, 1790.11it/s]
100%|██████████| 1000/1000 [00:03<00:00, 332.19it/s]
100%|██████████| 1000/1000 [00:35<00:00, 28.05it/s]
```

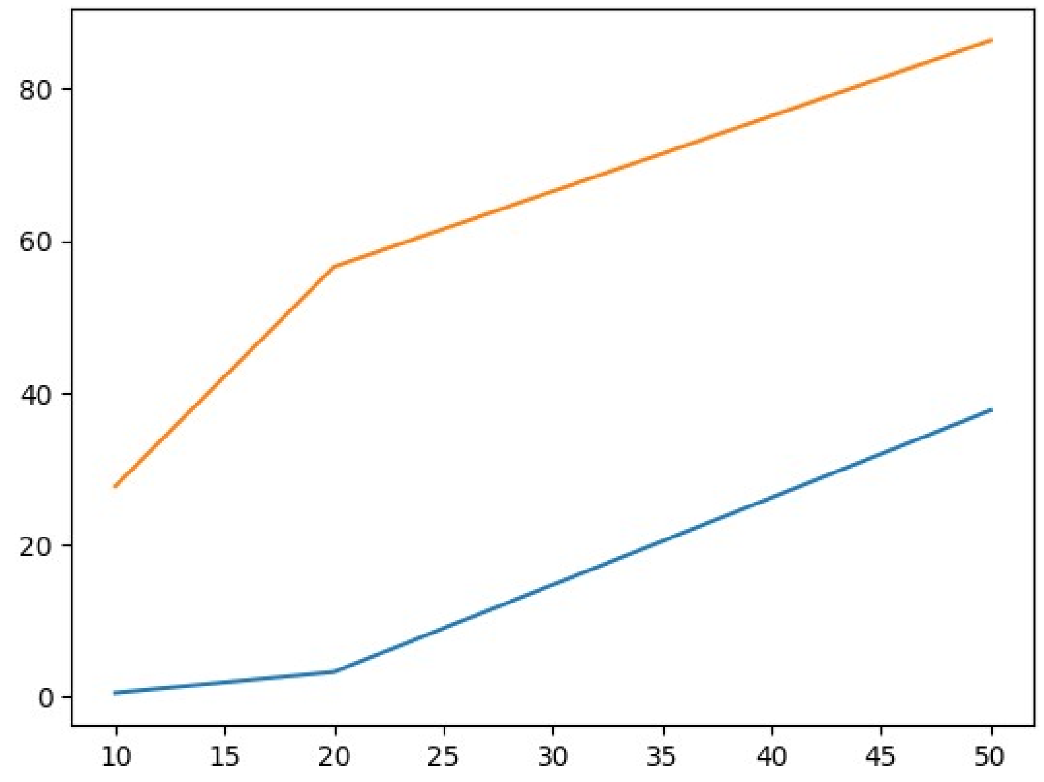
```
time_taken_created = 0
floyd_own_algorithm = []
#For created floyd algorithm for 10, 20, 50 nodes graph
for node in nodes_for_floyd:
    for i in tqdm(range(NUM_OF_ITERATIONS)):
        geaph_for_created = gnp_random_connected_graph(node, 0.01,
False)

        #measure time while algorithm is working
        start = time.time() #start
        floydworshal_algorithm(graph_for_imported, True)
        end = time.time() #end
        time_taken_created += end - start
    floyd_own_algorithm.append(time_taken_created)
    time_taken_created / NUM_OF_ITERATIONS
```

```
100%|██████████| 1000/1000 [00:28<00:00, 35.64it/s]
100%|██████████| 1000/1000 [00:29<00:00, 33.93it/s]
100%|██████████| 1000/1000 [00:31<00:00, 32.15it/s]
```

Here you can see comparing native and created algorithms and a graph that shows diference in time

```
plt.plot(nodes_for_floyd, floyd_native_algorithm)
plt.plot(nodes_for_floyd, floyd_own_algorithm)
plt.show()
```



As you can see, created algorithm is always much slower than native one. This is because the native algorithm is optimally written by professionals

Conslusion

As we can see we are able to create our own algorithms, but they will not be so fast as we want. So, instead of creating, we can use built-in algorithms. Or, also, it is possible to raise programming skills and create as fast created algorithms as native ones.