single_pop_sir

February 21, 2021

[342]:
```
import networkx as nx
import matplotlib.pyplot as plt
import numpy.random as random
```

[333]:
```
color_map = {"s": "blue", "i": "red", "r": "gray"}
options = {
    "node_size": 100,
    "arrowstyle": "-|>",
    "arrowsize": 12
}
```

[334]:
```
beta = 0.50
gamma = 0.50
N = 20
random.seed(1)
```

[335]:
```
G = nx.Graph()
G.add_nodes_from(range(N))
for i in range(len(G.nodes)):
    G.nodes[i]["group"] = "s"
G.nodes[0]["group"] = "i"
G.nodes[0]["recovery_time_left"] = 1
G.nodes.data()
```

[335]:
```
NodeDataView({0: {'group': 'i', 'recovery_time_left': 1}, 1: {'group': 's'}, 2:
{'group': 's'}, 3: {'group': 's'}, 4: {'group': 's'}, 5: {'group': 's'}, 6:
{'group': 's'}, 7: {'group': 's'}, 8: {'group': 's'}, 9: {'group': 's'}, 10:
{'group': 's'}, 11: {'group': 's'}, 12: {'group': 's'}, 13: {'group': 's'}, 14:
{'group': 's'}, 15: {'group': 's'}, 16: {'group': 's'}, 17: {'group': 's'}, 18:
{'group': 's'}, 19: {'group': 's'}})
```

[336]:
```
# Randomly make edges
for i in range(35):

    # Randomly decide two nodes
    node1 = random.randint(N)
    node2 = random.randint(N)
    while node2 == node1:
        node2 = random.randint(N)
    G.add_weighted_edges_from([(node1, node2, 0)])
```

[337]:

```
for node in G.nodes.data():
    if node[1]["group"] == "i":
        # All other nodes are suspected to be infected!
        for other_node in G.neighbors(node[0]):
            G[node[0]][other_node]["weight"] = beta
G.edges.data()
```

[337]:

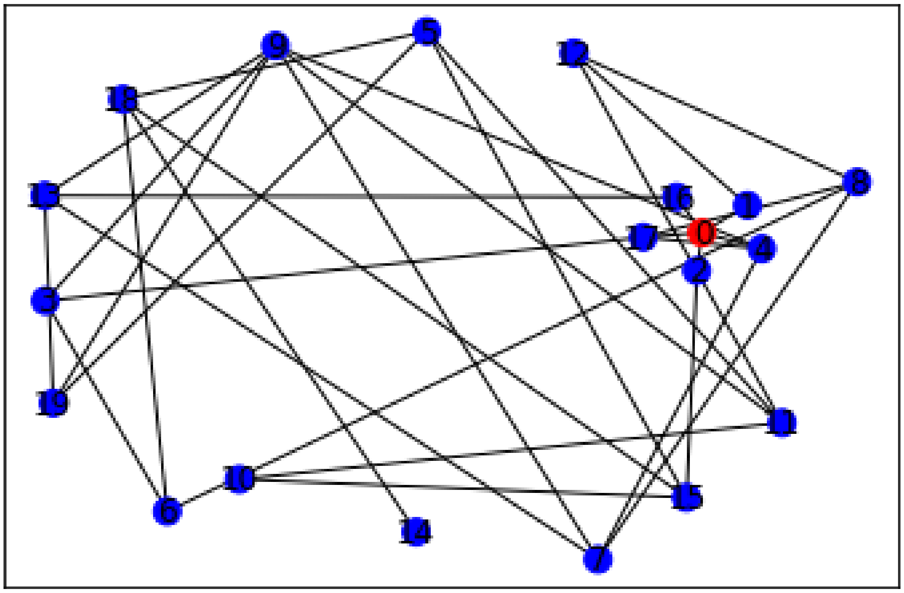
```
EdgeDataView([(0, 16, {'weight': 0.5}), (0, 17, {'weight': 0.5}), (0, 1,
{'weight': 0.5}), (0, 4, {'weight': 0.5}), (0, 2, {'weight': 0.5}), (1, 12,
{'weight': 0}), (2, 15, {'weight': 0}), (3, 6, {'weight': 0}), (3, 17,
{'weight': 0}), (3, 9, {'weight': 0}), (4, 9, {'weight': 0}), (4, 17, {'weight':
0}), (4, 7, {'weight': 0}), (5, 11, {'weight': 0}), (5, 15, {'weight': 0}), (5,
18, {'weight': 0}), (5, 19, {'weight': 0}), (6, 18, {'weight': 0}), (6, 8,
{'weight': 0}), (7, 13, {'weight': 0}), (7, 9, {'weight': 0}), (7, 8, {'weight':
0}), (8, 12, {'weight': 0}), (8, 17, {'weight': 0}), (9, 11, {'weight': 0}), (9,
13, {'weight': 0}), (9, 19, {'weight': 0}), (10, 11, {'weight': 0}), (10, 15,
{'weight': 0}), (11, 12, {'weight': 0}), (13, 19, {'weight': 0}), (13, 16,
{'weight': 0}), (14, 18, {'weight': 0}), (15, 18, {'weight': 0})])
```

[338]:

```
G_over_time = []
```

[339]:

```
def plot_G(G):
    pos=nx.spring_layout(G) # pos = nx.nx_agraph.graphviz_layout(G)
    labels = nx.get_edge_attributes(G,'weight')
    nx.draw_networkx(G, pos, node_color = [color_map[G.nodes[i]["group"]] for i␣
 ↪in G], **options)
    #nx.draw_networkx_edge_labels(G,pos,edge_labels=labels)
plot_G(G)
```

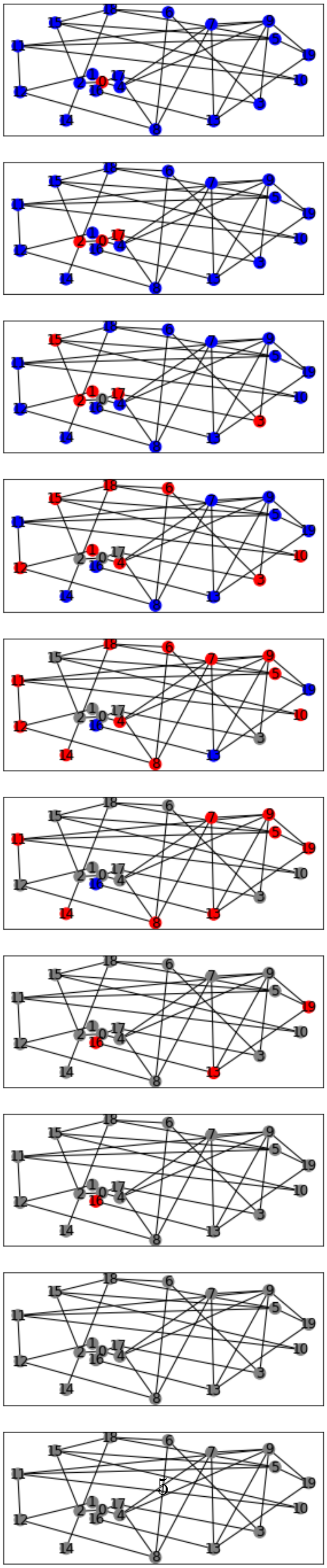


[340]:

```python
def infect_neighbors(G):
    for node in G.nodes.data():
        if node[1]["group"] == "i" and node[1]["recovery_time_left"] != 1:

            # Gives a chance to be infected with all neighbors
            for neighbor in G.neighbors(node[0]):
                if G.nodes[neighbor]["group"] == "s" and random.rand() < beta:
                    # neighbor got infected :(
                    G[node[0]][neighbor]["weight"] = 0
                    G.nodes[neighbor]["group"] = "i"
                    G.nodes[neighbor]["recovery_time_left"] = 1

                    # Updates the neighbors
                    for infected_neighbor in G.neighbors(neighbor):
                        if G.nodes[infected_neighbor]["group"] == "s":
                            G[neighbor][infected_neighbor]["weight"] = beta

def recover_infected(G):
    for node in G.nodes.data():
        if node[1]["group"] == "i":
            # Add to the recovery rate
            node[1]["recovery_time_left"] -= gamma

            # Checks if they have recovered
            if node[1]["recovery_time_left"] < 0:
                # They are recovered
                node[1]["group"] = "r"
                # Updates all of the neighbors
                for neighbor in G.neighbors(node[0]):
                    G[node[0]][neighbor]["weight"] = 0

for i in range(10):

    # Infect new individuals
    infect_neighbors(G)

    # See which infected get recovered
    recover_infected(G)

    G_over_time.append(G.copy())
```

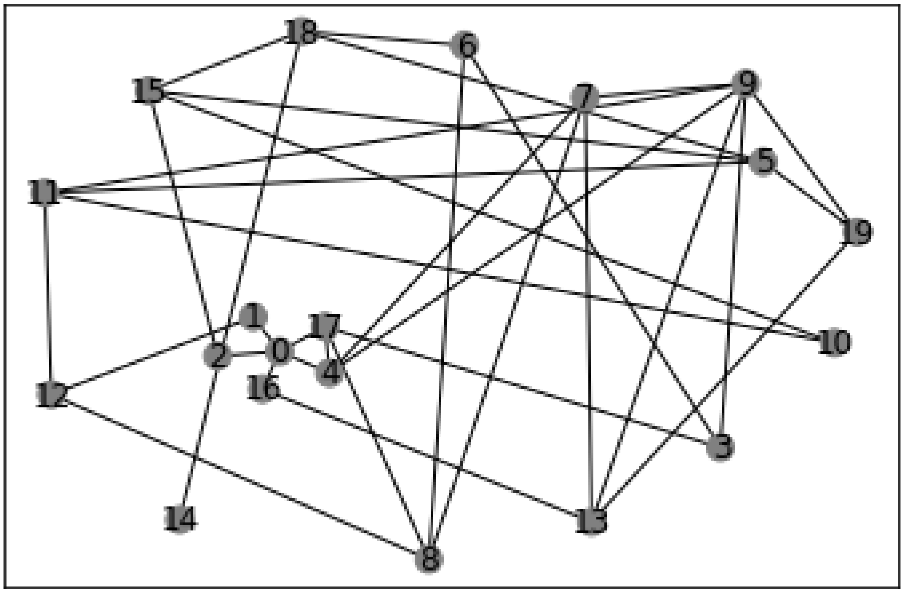
[341]:

```
fig, axs = plt.subplots(len(G_over_time), figsize = (5, 25))
pos = nx.spring_layout(G_over_time[0])
for i in range(len(G_over_time)):
    curr_G = G_over_time[i]
    nx.draw_networkx(curr_G, pos, node_color = [color_map[curr_G.
 ↪nodes[i]["group"]] for i in curr_G], **options, ax = axs[i])
```


0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19

[361]:
```
from IPython.display import HTML
fig, ax = plt.subplots()
def animate(i):
    ax.clear()
    curr_G = G_over_time[i]
    nx.draw_networkx(curr_G, pos, node_color = [color_map[curr_G.
 ↪nodes[i]["group"]] for i in curr_G], **options, ax = ax)
ani = FuncAnimation(fig, animate, frames = len(G_over_time), interval = 1000)
HTML(ani.to_jshtml())
```

[361]:
```
<IPython.core.display.HTML object>
```



[363]:
```
nx.adjacency_matrix(G_over_time[0]).todense()
```

[363]:
```
matrix([[0. , 0.5, 0.5, 0. , 0.5, 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
          0. , 0. , 0. , 0.5, 0.5, 0. , 0. ],
         [0.5, 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
          0. , 0. , 0. , 0. , 0. , 0. , 0. ],
         [0.5, 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
          0. , 0. , 0. , 0. , 0. , 0. , 0. ],
         [0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
          0. , 0. , 0. , 0. , 0. , 0. , 0. ],
         [0.5, 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
          0. , 0. , 0. , 0. , 0. , 0. , 0. ],
[0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
 0. , 0. , 0. , 0. , 0. , 0. , 0. ],
[0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
 0. , 0. , 0. , 0. , 0. , 0. , 0. ],
[0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
 0. , 0. , 0. , 0. , 0. , 0. , 0. ],
[0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
 0. , 0. , 0. , 0. , 0. , 0. , 0. ],
[0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
 0. , 0. , 0. , 0. , 0. , 0. , 0. ],
[0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
 0. , 0. , 0. , 0. , 0. , 0. , 0. ],
[0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
 0. , 0. , 0. , 0. , 0. , 0. , 0. ],
[0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
 0. , 0. , 0. , 0. , 0. , 0. , 0. ],
[0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
 0. , 0. , 0. , 0. , 0. , 0. , 0. ],
[0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
 0. , 0. , 0. , 0. , 0. , 0. , 0. ],
[0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
 0. , 0. , 0. , 0. , 0. , 0. , 0. ],
[0.5, 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
 0. , 0. , 0. , 0. , 0. , 0. , 0. ],
[0.5, 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
 0. , 0. , 0. , 0. , 0. , 0. , 0. ],
[0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
 0. , 0. , 0. , 0. , 0. , 0. , 0. ],
[0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. , 0. ,
 0. , 0. , 0. , 0. , 0. , 0. , 0. ]])
```