Untitled

May 23, 2020

[156]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt

data = pd.read_csv('Japan.csv')
pd.set_option("max_rows", None)
pd.set_option("max_columns", None)
display(data)
```

	Date	Infected	Confirmed	Tested	Susceptible	Active	Active/Infected	\
0	1-Apr	1992	280	2011	0.139234	227	0.113956	
1	2-Apr	2244	284	2002	0.141858	252	0.112299	
2	3-Apr	2553	336	2936	0.114441	309	0.121034	
3	4-Apr	2857	371	3436	0.107974	304	0.106405	
4	5-Apr	3178	351	1757	0.199772	321	0.101007	
5	6-Apr	3412	234	1533	0.152642	234	0.068581	
6	7-Apr	3748	374	9139	0.040924	336	0.089648	
7	8-Apr	4273	536	6187	0.086633	525	0.122864	
8	9-Apr	4857	594	2889	0.205607	584	0.120239	
9	10-Apr	5449	637	4384	0.145301	592	0.108644	
10	11-Apr	6027	701	6120	0.114542	578	0.095902	
11	12-Apr	6551	519	2490	0.208434	524	0.079988	
12	13-Apr	6823	296	1321	0.224073	272	0.039865	
13	14-Apr	7255	505	10849	0.046548	432	0.059545	
14	15-Apr	7745	558	4685	0.119104	490	0.063267	
15	16-Apr	8225	562	6467	0.086903	480	0.058359	
16	17-Apr	8686	558	5669	0.098430	461	0.053074	
17	18-Apr	9192	589	5159	0.114169	506	0.055048	
18	19-Apr	9197	364	1285	0.283268	5	0.000544	
19	20-Apr	9434	343	3909	0.087746	237	0.025122	
20	21-Apr	9378	383	7825	0.048946	-56	-0.005971	
21	22-Apr	9726	398	6037	0.065927	348	0.035780	
22	23-Apr	9758	434	5396	0.080430	32	0.003279	
23	24-Apr	10079	381	5617	0.067830	321	0.031848	
24	25-Apr	10235	320	5854	0.054663	156	0.015242	
25	26-Apr	10256	213	1620	0.131481	21	0.002048	
26	27-Apr	10194	170	1618	0.105068	-62	-0.006082	
27	28-Apr	10089	283	9854	0.028719	-105	-0.010407	

28	29-Apr	10075	219	3709	0.059046	-14	-0.001390
29	30-Apr	9996	193	1354	0.142541	-79	-0.007903
30	1-May	9822	273	8541	0.031963	-174	-0.017715
31	2-May	9929	304	7377	0.041209	107	0.010777
32	3-May	9913	198	1724	0.114849	-16	-0.001614
33	4-May	9886	167	1335	0.125094	-27	-0.002731
34	5-May	9366	125	1757	0.071144	-520	-0.055520
35	6-May	9185	101	2584	0.039087	-181	-0.019706
36	7-May	7813	98	1103	0.088849	-1372	-0.175605
37	8-May	7186	89	11983	0.007427	-627	-0.087253
38	9-May	6857	114	9984	0.011418	-329	-0.047980
39	10-May	6652	69	2259	0.030544	-205	-0.030818

	Recovered	Recovered/Infected	Deaths	Deaths/Infected
0	48	0.024096	5	0.002510
1	29	0.012923	3	0.001337
2	21	0.008226	6	0.002350
3	61	0.021351	6	0.002100
4	24	0.007552	6	0.001888
5	-3	-0.000879	3	0.000879
6	36	0.009605	2	0.000534
7	4	0.000936	7	0.001638
8	2	0.000412	8	0.001647
9	33	0.006056	12	0.002202
10	110	0.018251	13	0.002157
11	-14	-0.002137	9	0.001374
12	15	0.002198	9	0.001319
13	59	0.008132	14	0.001930
14	52	0.006714	16	0.002066
15	64	0.007781	18	0.002188
16	84	0.009671	13	0.001497
17	65	0.007071	18	0.001958
18	340	0.036969	19	0.002066
19	86	0.009116	20	0.002120
20	412	0.043933	27	0.002879
21	30	0.003085	20	0.002056
22	374	0.038328	28	0.002869
23	51	0.005060	9	0.000893
24	145	0.014167	19	0.001856
25	177	0.017258	15	0.001463
26	210	0.020600	22	0.002158
27	370	0.036674	18	0.001784
28	215	0.021340	18	0.001787
29	245	0.024510	27	0.002701
30	418	0.042558	29	0.002953
31	172	0.017323	25	0.002518
32	191	0.019268	23	0.002320
33	175	0.017702	19	0.001922

34	635	0.067798	10	0.001068
35	271	0.029505	11	0.001198
36	1459	0.186740	11	0.001408
37	701	0.097551	15	0.002087
38	425	0.061980	18	0.002625
39	262	0.039387	12	0.001804

[157]:

```
#CleanData
#Japan has a population of 126.5 million and they test like 4500 people
#a day, and everyone is wondering why their death rate is lower than
#a normal disease, so i just took the number of tested people (265000)
#and used that as the population representing a worst case scenario i suppose
#But i think its pretty obvious most people don't go and get tested for covid␣
↪there
#Use number of people tested as sample size of population
cData = data[['Tested', 'Active', 'Recovered', 'Deaths']]
display(cData)
```

	Tested	Active	Recovered	Deaths
0	2011	227	48	5
1	2002	252	29	3
2	2936	309	21	6
3	3436	304	61	6
4	1757	321	24	6
5	1533	234	-3	3
6	9139	336	36	2
7	6187	525	4	7
8	2889	584	2	8
9	4384	592	33	12
10	6120	578	110	13
11	2490	524	-14	9
12	1321	272	15	9
13	10849	432	59	14
14	4685	490	52	16
15	6467	480	64	18
16	5669	461	84	13
17	5159	506	65	18
18	1285	5	340	19
19	3909	237	86	20
20	7825	-56	412	27
21	6037	348	30	20
22	5396	32	374	28
23	5617	321	51	9
24	5854	156	145	19
25	1620	21	177	15
26	1618	-62	210	22
27	9854	-105	370	18

```
28     3709     -14        215       18
29     1354     -79        245       27
30     8541    -174        418       29
31     7377     107        172       25
32     1724     -16        191       23
33     1335     -27        175       19
34     1757    -520        635       10
35     2584    -181        271       11
36     1103   -1372       1459       11
37    11983    -627        701       15
38     9984    -329        425       18
39     2259    -205        262       12
```

[158]:

```python
#Change to numpy arrays
tested = np.asarray(data['Tested'])
population = np.zeros(30)
#np.set_printoptions(precision=4)
np.set_printoptions(suppress=True)


print("Population Array:")
for i in range(30):
    population[i] = 265000
print(population)

print("Original Tested:")
print(tested[0:30])

print("Original Active:")
active = np.asarray(data['Active'])
print(active[0:30])


print("Original Recovered:")
recovered = np.asarray(data['Recovered'])
print(recovered[0:30])

print("Original Deaths:")
deaths= np.asarray(data['Deaths'])
print(deaths[0:30])
```

```
Population Array:
[265000. 265000. 265000. 265000. 265000. 265000. 265000. 265000. 265000.
 265000. 265000. 265000. 265000. 265000. 265000. 265000. 265000. 265000.
 265000. 265000. 265000. 265000. 265000. 265000. 265000. 265000. 265000.
 265000. 265000. 265000.]
Original Tested:
```

```
[ 2011  2002  2936  3436  1757  1533  9139  6187  2889  4384  6120  2490
  1321 10849  4685  6467  5669  5159  1285  3909  7825  6037  5396  5617
  5854  1620  1618  9854  3709  1354]
Original Active:
[ 227  252  309  304  321  234  336  525  584  592  578  524  272  432
  490  480  461  506    5  237  -56  348   32  321  156   21  -62 -105
  -14  -79]
Original Recovered:
[ 48  29  21  61  24  -3  36   4   2  33 110 -14  15  59  52  64  84  65
 340  86 412  30 374  51 145 177 210 370 215 245]
Original Deaths:
[ 5  3  6  6  6  3  2  7  8 12 13  9  9 14 16 18 13 18 19 20 27 20 28  9
 19 15 22 18 18 27]
```

[159]:

```
#Get x1 -> x30
x = np.zeros((30,4))

for i in range(30):
    if ( i == 0 ):
        x[i][0] = population[i]
        x[i][1] = active[i]
        x[i][2] = recovered[i]
        x[i][3] = deaths[i]
    else:
        change = (active[i] + recovered[i] + deaths[i]) - (active[i-1] +
 ↪recovered[i-1] + deaths[i-1])
        x[i][0] = 265000 - change
        x[i][1] = active[i]
        x[i][2] = recovered[i]
        x[i][3] = deaths[i]

print("x1 ... x30:")
print(x)
```

```
x1 … x30:
[[265000.    227.     48.      5.]
 [264996.    252.     29.      3.]
 [264948.    309.     21.      6.]
 [264965.    304.     61.      6.]
 [265020.    321.     24.      6.]
 [265117.    234.     -3.      3.]
 [264860.    336.     36.      2.]
 [264838.    525.      4.      7.]
 [264942.    584.      2.      8.]
 [264957.    592.     33.     12.]
 [264936.    578.    110.     13.]
 [265182.    524.    -14.      9.]
 [265223.    272.     15.      9.]
```

```
 [264791.    432.     59.     14.]
 [264947.    490.     52.     16.]
 [264996.    480.     64.     18.]
 [265004.    461.     84.     13.]
 [264969.    506.     65.     18.]
 [265225.      5.    340.     19.]
 [265021.    237.     86.     20.]
 [264960.    -56.    412.     27.]
 [264985.    348.     30.     20.]
 [264964.     32.    374.     28.]
 [265053.    321.     51.      9.]
 [265061.    156.    145.     19.]
 [265107.     21.    177.     15.]
 [265043.    -62.    210.     22.]
 [264887.   -105.    370.     18.]
 [265064.    -14.    215.     18.]
 [265026.    -79.    245.     27.]]
```

[160]:

```python
#Calculate a, b, c, d, e for transition matrixes
a = np.zeros(29)
for i in range(29):
    a[i] = x[i+1][0]/x[i][0]

d = np.zeros(29)
for i in range(29):
    d[i] = (x[i+1][2] - x[i][2])/x[i][1]

e = np.zeros(29)
for i in range(29):
    e[i] = (x[i+1][3] - x[i][3])/x[i][1]

c = np.zeros(29)
for i in range(29):
    c[i] = 1 - d[i] - e[i]

b = np.zeros(29)
for i in range(29):
    b[i] = (x[i+1][1] - (x[i][1] * c[i]))/x[i][0]

print("a:")
print(a)
print("b:")
print(b)
print("c:")
print(c)
print("d:")
print(d)
```

```python
print("e:")
print(e)
```

```
a:
[0.9999849057 0.9998188652 1.0000641635 1.0002075746 1.0003660101
 0.9990306167 0.9999169372 1.0003926929 1.0000566162 0.9999207419
 1.0009285261 1.0001546108 0.998371182  1.0005891439 1.0001849426
 1.0000301891 0.9998679265 1.0009661508 0.9992308417 0.9997698296
 1.0000943539 0.9999207502 1.0003358947 1.0000301826 1.000173545
 0.999758588  0.9994114163 1.0006682095 0.9998566384]
b:
[ 0.0000150943  0.0001962294  0.0001321014 -0.0000754817 -0.0004414761
  0.0005280687  0.0006116439  0.0002190018  0.0001622997  0.0002415486
 -0.0006869584 -0.0008409319  0.0007880161  0.0002001579  0.0000150974
 -0.0000150946  0.0001169794 -0.0008491559 -0.0000791781  0.0001509314
  0.0000566123  0.0001358567 -0.0002000272 -0.0002301427 -0.0004036807
 -0.0001621987  0.0004263459 -0.0002416125 -0.0000980895]
c:
[ 1.0925110132  1.0198412698  0.8705501618  1.1217105263  1.0934579439
  0.8376068376  1.0803571429  1.0019047619  0.9400684932  0.8682432432
  1.2214532872  0.9446564885  0.8198529412  1.0115740741  0.9714285714
  0.96875       1.0303687636  0.4545454545 51.6          -0.4050632911
 -5.9464285714 -0.0114942529 11.6875        0.6760124611  0.8205128205
 -0.9047619048  3.5161290323 -0.4761904762  3.7857142857]
d:
[ -0.0837004405  -0.0317460317   0.1294498382  -0.1217105263
  -0.0841121495   0.1666666667  -0.0952380952  -0.0038095238
   0.0530821918   0.1300675676  -0.214532872    0.0553435115
   0.1617647059  -0.0162037037   0.0244897959   0.0416666667
  -0.0412147505   0.5434782609 -50.8            1.3755274262
   6.8214285714   0.9885057471 -10.09375        0.292834891
   0.2051282051   1.5714285714  -2.5806451613   1.4761904762
  -2.1428571429]
e:
[-0.0088105727  0.0119047619  0.            0.           -0.0093457944
 -0.0042735043  0.0148809524  0.0019047619  0.0068493151  0.0016891892
 -0.0069204152  0.            0.0183823529  0.0046296296  0.0040816327
 -0.0104166667  0.010845987   0.0019762846  0.2           0.029535865
  0.125         0.0229885057 -0.59375       0.031152648  -0.0256410256
  0.3333333333  0.064516129  -0.           -0.6428571429]
```

[161]:
```python
#Create model matrix A
ak = np.mean(a)
print("ak:")
print(ak)

bk = np.mean(b)
```

```python
print("bk:")
print(bk)

ck = np.mean(c)
print("ck")
print(ck)

dk = np.mean(d)
print("dk")
print(dk)

ek = np.mean(e)
print("ek")
print(ek)

A = np.array([[ak, 0, 0, 0], [bk, ck, 0, 0], [0, dk, 1, 0], [0, ek, 0, 1]])
np.set_printoptions(precision=10)
print("A:")
print(A)
```

```
ak:
1.0000035188148835
bk:
-1.1311819028120678e-05
ck
2.816924519915608
dk
-1.8024988725557984
ek
-0.014425647359809678
A:
[[ 1.0000035188  0.            0.            0.          ]
 [-0.0000113118  2.8169245199  0.            0.          ]
 [ 0.           -1.8024988726  1.            0.          ]
 [ 0.           -0.0144256474  0.            1.          ]]
```

[163]:

```python
#Predicted and actual results for May 1-10
#apr30 = np.zeros((4,1))
#apr30[0][0] = 265026
#apr30[1][0] = -79
#apr30[2][0] = 245
#apr30[3][0] = 27
apr30 = np.array([265026, -79,245, 27])

print("April 30:")
print(apr30)
pmay1 = A.dot(apr30)
```

```
print("Predicted May 1")
print(pmay1)
pmay2 = A.dot(pmay1)
print("Predicted May 2")
print(pmay2)
pmay3 = A.dot(pmay2)
print("Predicted May 3")
print(pmay3)
pmay4 = A.dot(pmay3)
print("Predicted May 4")
print(pmay4)
pmay5 = A.dot(pmay4)
print("Predicted May 5")
print(pmay5)
pmay6 = A.dot(pmay5)
print("Predicted May 6")
print(pmay6)
pmay7 = A.dot(pmay6)
print("Predicted May 7")
print(pmay7)
pmay8 = A.dot(pmay7)
print("Predicted May 8")
print(pmay8)
pmay9 = A.dot(pmay8)
print("Predicted May 9")
print(pmay9)
pmay10 = A.dot(may9)
print("Predicted May 10")
print(pmay10)

print("Actual Results")
m = np.zeros((10, 4))
counter = 0
for i in range(29, 39):
    if ( i == 29 ):
        m[counter] = x[i]
        counter = counter + 1
    else:
        change = (active[i] + recovered[i] + deaths[i]) - (active[i-1] + 
 ↪recovered[i-1] + deaths[i-1])
        m[counter][0] = m[0][0] - change
        m[counter][1] = active[i]
        m[counter][2] = recovered[i]
        m[counter][3] = deaths[i]
        counter = counter + 1

print("m1 ... m10:")
```

```
print(m)
```

```
April 30:
[265026    -79    245     27]
Predicted May 1
[265026.9325774333   -225.5349632231    387.3974109319     28.1396261414]
Predicted May 2
[265027.8651581482   -638.3129047003    793.9239278634     31.3931139882]
Predicted May 3
[265028.7977421446  -1801.0772198768   1944.4822189234     40.6011908566]
Predicted May 4
[265029.7303294226  -5076.4965407296   5190.9218771373     66.5828956983]
Predicted May 5
[265030.6629199823 -14303.1055491946  14341.3011683358    139.8146446182]
Predicted May 6
[265031.5955138236 -40293.7667113631  40122.6327948056    346.146201421 ]
Predicted May 7
[ 265032.5281109465 -113507.4974384431  112752.1018630639
     927.4098707976]
Predicted May 8
[ 265033.460711351  -319745.050728603   317349.2380224877
    2564.8290015391]
Predicted May 9
[ 265034.3933150372 -900700.6715296056  893689.3314660912
    7177.3583483943]
Predicted May 10
[  265035.325922005  -2537208.8047572933  2517201.276408456
    20170.5486126242]
Actual Results
m1 … m10:
[[265026.    -79.    245.     27.]
 [264946.   -174.    418.     29.]
 [264995.    107.    172.     25.]
 [265132.    -16.    191.     23.]
 [265057.    -27.    175.     19.]
 [265068.   -520.    635.     10.]
 [265050.   -181.    271.     11.]
 [265029.  -1372.   1459.     11.]
 [265035.   -627.    701.     15.]
 [265001.   -329.    425.     18.]]
```

[164]:
```
#Rearrange arrays for modeling
pi = np.array([pmay1[1], pmay2[1], pmay3[1], pmay4[1], pmay5[1], pmay6[1],␣
 ↪pmay7[1], pmay8[1], pmay9[1], pmay10[1]])
print("Predicted Infected:")
print(pi)
```

```
pr = np.array([pmay1[2], pmay2[2], pmay3[2], pmay4[2], pmay5[2], pmay6[2],␣
 ↪pmay7[2], pmay8[2], pmay9[2], pmay10[2]])
print("Predicted Recovered:")
print(pr)
pd = np.array([pmay1[3], pmay2[3], pmay3[3], pmay4[3], pmay5[3], pmay6[3],␣
 ↪pmay7[3], pmay8[3], pmay9[3], pmay10[3]])
print("Predicted Deaths:")
print(pd)
ri = np.array([m[0][1], m[1][1], m[2][1], m[3][1], m[4][1], m[5][1], m[6][1],␣
 ↪m[7][1], m[8][1], m[9][1]])
print("Real Infected:")
print(ri)
rr = np.array([m[0][2], m[1][2], m[2][2], m[3][2], m[4][2], m[5][2], m[6][2],␣
 ↪m[7][2], m[8][2], m[9][2]])
print("Real Recovered:")
print(rr)
rd = np.array([m[0][3], m[1][3], m[2][3], m[3][3], m[4][3], m[5][3], m[6][3],␣
 ↪m[7][3], m[8][3], m[9][3]])
print("Real Deaths:")
print(rd)
```

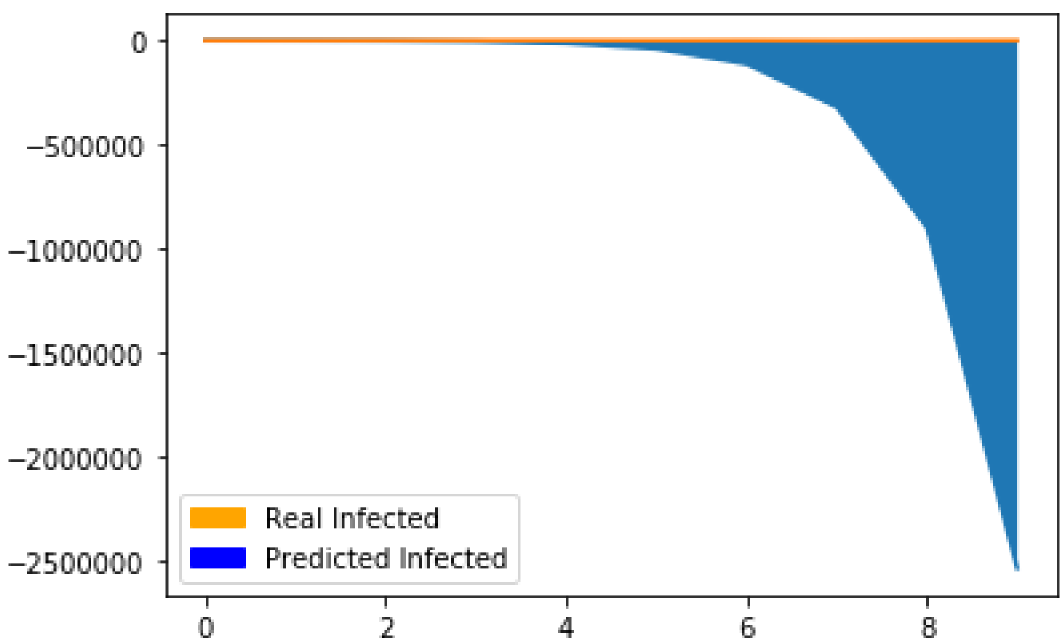
```
Predicted Infected:
[    -225.5349632231     -638.3129047003    -1801.0772198768
    -5076.4965407296   -14303.1055491946   -40293.7667113631
  -113507.4974384431  -319745.050728603   -900700.6715296056
 -2537208.8047572933]
Predicted Recovered:
[    387.3974109319     793.9239278634    1944.4822189234
    5190.9218771373   14341.3011683358   40122.6327948056
  112752.1018630639  317349.2380224877  893689.3314660912
 2517201.276408456 ]
Predicted Deaths:
[   28.1396261414    31.3931139882    40.6011908566    66.5828956983
   139.8146446182   346.146201421     927.4098707976  2564.8290015391
  7177.3583483943 20170.5486126242]
Real Infected:
[  -79.  -174.   107.   -16.   -27.  -520.  -181. -1372.  -627.  -329.]
Real Recovered:
[ 245.  418.  172.  191.  175.  635.  271. 1459.  701.  425.]
Real Deaths:
[27. 29. 25. 23. 19. 10. 11. 11. 15. 18.]
```

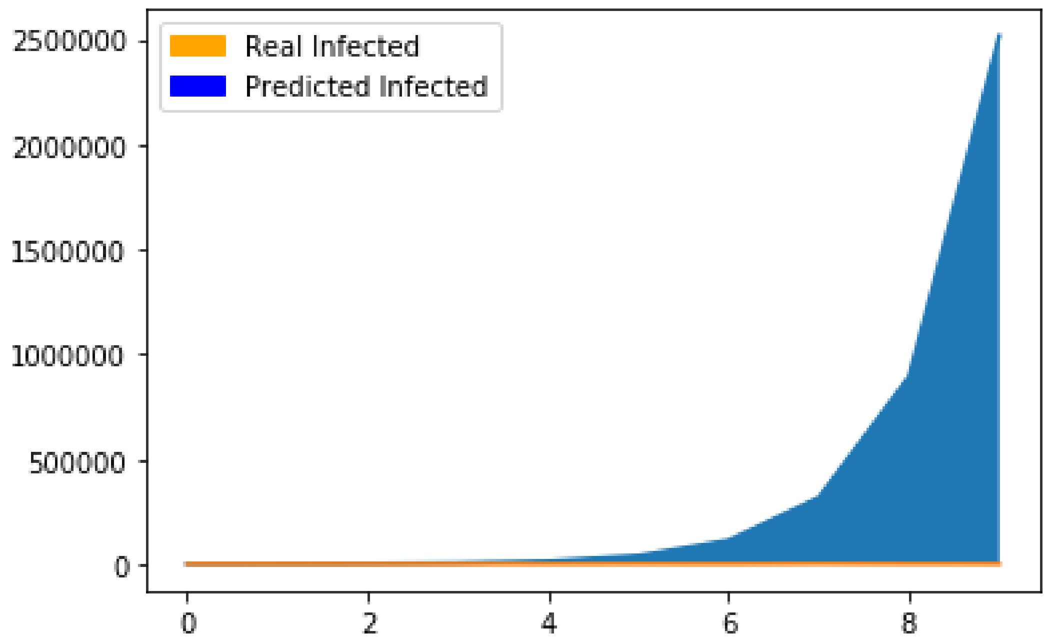
[166]:

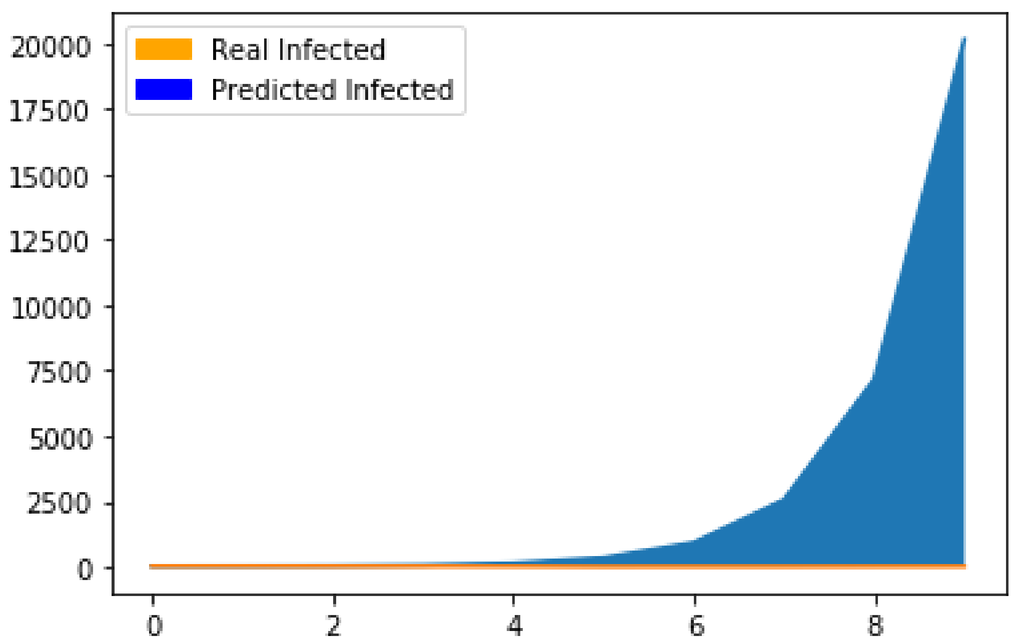
```
#Graph
import matplotlib.patches as mpatches

z = [0,1,2,3,4,5,6,7,8,9]
plt.plot(pi)
```

```
plt.plot(ri)
blue = mpatches.Patch(color='blue', label='Predicted Infected')
orange = mpatches.Patch(color='orange', label='Real Infected ')
plt.legend(handles=[orange, blue])
plt.fill_between(z, pi, ri)
plt.show()
plt.plot(pr)
plt.plot(rr)
blue = mpatches.Patch(color='blue', label='Predicted Infected')
orange = mpatches.Patch(color='orange', label='Real Infected ')
plt.legend(handles=[orange, blue])
plt.fill_between(z, pr, rr)
plt.show()
plt.plot(pd)
plt.plot(rd)
blue = mpatches.Patch(color='blue', label='Predicted Infected')
orange = mpatches.Patch(color='orange', label='Real Infected ')
plt.legend(handles=[orange, blue])
plt.fill_between(z, pd, rd)
plt.show()
```







Unfortunately my model does not fit very well at all. I think that the data from Japan is not only inaccurate, but inconsistent as well. The volatility of the number of actively infected and recovered people in the second half of April really messes with the results. There are also many negative numbers, as the number of infected drops dramatically and the number of recovered spikes. But once again all these numbers are very different from day to day so it would be hard to find a pattern in this short of time. The time frame of this assignment is another thing that really skews my results, as halfway through April, everyone seems to be getting cured. Looking at Japan's data, if someone didn't tell you it was covid data, you would never know because the numbers are so low and insignificant. I do think there are better ways to find a predictive model, but the Markov Model doesn't take the volatility very well. Reading more into Japan's low numbers, it seems like they just aren't testing much, and most people are being told to stay home so that panic will not spread. So basically I don't trust the data itself. One way to make the model look more like what we are looking for would be to just take the data from the first half of April, where the data looks more consistent.

[167]:
```
#Change to numpy arrays
tested = np.asarray(data['Tested'])
population = np.zeros(17)
#np.set_printoptions(precision=4)
np.set_printoptions(suppress=True)


print("Population Array:")
for i in range(17):
    population[i] = 265000
print(population)

print("Original Tested:")
print(tested[0:17])

print("Original Active:")
active = np.asarray(data['Active'])
print(active[0:17])


print("Original Recovered:")
recovered = np.asarray(data['Recovered'])
print(recovered[0:17])

print("Original Deaths:")
deaths= np.asarray(data['Deaths'])
print(deaths[0:17])
```

```
Population Array:
[265000. 265000. 265000. 265000. 265000. 265000. 265000. 265000. 265000.
 265000. 265000. 265000. 265000. 265000. 265000. 265000. 265000.]
Original Tested:
[ 2011  2002  2936  3436  1757  1533  9139  6187  2889  4384  6120  2490
  1321 10849  4685  6467  5669]
Original Active:
[227 252 309 304 321 234 336 525 584 592 578 524 272 432 490 480 461]
Original Recovered:
[ 48  29  21  61  24  -3  36   4   2  33 110 -14  15  59  52  64  84]
```

```
Original Deaths:
[ 5  3  6  6  6  3  2  7  8 12 13  9  9 14 16 18 13]
```

[168]:
```python
#Get x1 -> x17
x = np.zeros((17,4))

for i in range(17):
    if ( i == 0 ):
        x[i][0] = population[i]
        x[i][1] = active[i]
        x[i][2] = recovered[i]
        x[i][3] = deaths[i]
    else:
        change = (active[i] + recovered[i] + deaths[i]) - (active[i-1] +␣
 ↪recovered[i-1] + deaths[i-1])
        x[i][0] = 265000 - change
        x[i][1] = active[i]
        x[i][2] = recovered[i]
        x[i][3] = deaths[i]

print("x1 ... x17:")
print(x)
```

```
x1 … x17:
[[265000.    227.     48.      5.]
 [264996.    252.     29.      3.]
 [264948.    309.     21.      6.]
 [264965.    304.     61.      6.]
 [265020.    321.     24.      6.]
 [265117.    234.     -3.      3.]
 [264860.    336.     36.      2.]
 [264838.    525.      4.      7.]
 [264942.    584.      2.      8.]
 [264957.    592.     33.     12.]
 [264936.    578.    110.     13.]
 [265182.    524.    -14.      9.]
 [265223.    272.     15.      9.]
 [264791.    432.     59.     14.]
 [264947.    490.     52.     16.]
 [264996.    480.     64.     18.]
 [265004.    461.     84.     13.]]
```

[178]:
```python
#Calculate a, b, c, d, e for transition matrixes
a = np.zeros(16)
for i in range(16):
    a[i] = x[i+1][0]/x[i][0]
```

```python
d = np.zeros(16)
for i in range(16):
    d[i] = (x[i+1][2] - x[i][2])/x[i][1]

e = np.zeros(16)
for i in range(16):
    e[i] = (x[i+1][3] - x[i][3])/x[i][1]

c = np.zeros(16)
for i in range(16):
    c[i] = 1 - d[i] - e[i]

b = np.zeros(16)
for i in range(16):
    b[i] = (x[i+1][1] - (x[i][1] * c[i]))/x[i][0]

print("a:")
print(a)
print("b:")
print(b)
print("c:")
print(c)
print("d:")
print(d)
print("e:")
print(e)
```

```
a:
[0.9999849057 0.9998188652 1.0000641635 1.0002075746 1.0003660101
 0.9990306167 0.9999169372 1.0003926929 1.0000566162 0.9999207419
 1.0009285261 1.0001546108 0.998371182  1.0005891439 1.0001849426
 1.0000301891]
b:
[ 0.0000150943  0.0001962294  0.0001321014 -0.0000754817 -0.0004414761
  0.0005280687  0.0006116439  0.0002190018  0.0001622997  0.0002415486
 -0.0006869584 -0.0008409319  0.0007880161  0.0002001579  0.0000150974
 -0.0000150946]
c:
[1.0925110132 1.0198412698 0.8705501618 1.1217105263 1.0934579439
 0.8376068376 1.0803571429 1.0019047619 0.9400684932 0.8682432432
 1.2214532872 0.9446564885 0.8198529412 1.0115740741 0.9714285714
 0.96875     ]
d:
[-0.0837004405 -0.0317460317  0.1294498382 -0.1217105263 -0.0841121495
  0.1666666667 -0.0952380952 -0.0038095238  0.0530821918  0.1300675676
 -0.214532872   0.0553435115  0.1617647059 -0.0162037037  0.0244897959
  0.0416666667]
```

```
e:
[-0.0088105727  0.0119047619  0.            0.           -0.0093457944
 -0.0042735043  0.0148809524  0.0019047619  0.0068493151  0.0016891892
 -0.0069204152  0.            0.0183823529  0.0046296296  0.0040816327
 -0.0104166667]
```

[170]:

```
#Create model matrix A
ak = np.mean(a)
print("ak:")
print(ak)

bk = np.mean(b)
print("bk:")
print(bk)

ck = np.mean(c)
print("ck")
print(ck)

dk = np.mean(d)
print("dk")
print(dk)

ek = np.mean(e)
print("ek")
print(ek)

A = np.array([[ak, 0, 0, 0], [bk, ck, 0, 0], [0, dk, 1, 0], [0, ek, 0, 1]])
np.set_printoptions(precision=10)
print("A:")
print(A)
```

```
ak:
1.0000011074067308
bk:
6.55822867141592e-05
ck
0.9914979222686928
dk
0.006967350079607507
ek
0.0015347276516995865
A:
[[1.0000011074 0.           0.           0.          ]
 [0.0000655823 0.9914979223 0.           0.          ]
 [0.           0.0069673501 1.           0.          ]
 [0.           0.0015347277 0.           1.          ]]
```

```
[171]: #Predicted and actual results for May 1-10
#apr30 = np.zeros((4,1))
#apr30[0][0] = 265026
#apr30[1][0] = -79
#apr30[2][0] = 245
#apr30[3][0] = 27
apr17 = np.array([265004,461,84,13])

print("April 17:")
print(apr17)
pmay1 = A.dot(apr17)
print("Predicted May 1")
print(pmay1)
pmay2 = A.dot(pmay1)
print("Predicted May 2")
print(pmay2)
pmay3 = A.dot(pmay2)
print("Predicted May 3")
print(pmay3)
pmay4 = A.dot(pmay3)
print("Predicted May 4")
print(pmay4)
pmay5 = A.dot(pmay4)
print("Predicted May 5")
print(pmay5)
pmay6 = A.dot(pmay5)
print("Predicted May 6")
print(pmay6)
pmay7 = A.dot(pmay6)
print("Predicted May 7")
print(pmay7)
pmay8 = A.dot(pmay7)
print("Predicted May 8")
print(pmay8)
pmay9 = A.dot(pmay8)
print("Predicted May 9")
print(pmay9)
pmay10 = A.dot(pmay9)
print("Predicted May 10")
print(pmay10)

print("Actual Results")
m = np.zeros((10, 4))
counter = 0
for i in range(29, 39):
    if ( i == 29 ):
        m[counter] = x[i-13]
```

```python
        counter = counter + 1
    else:
        change = (active[i] + recovered[i] + deaths[i]) - (active[i-1] +␣
↪recovered[i-1] + deaths[i-1])
        m[counter][0] = m[0][0] - change
        m[counter][1] = active[i]
        m[counter][2] = recovered[i]
        m[counter][3] = deaths[i]
        counter = counter + 1

print("m1 ... m10:")
print(m)
```

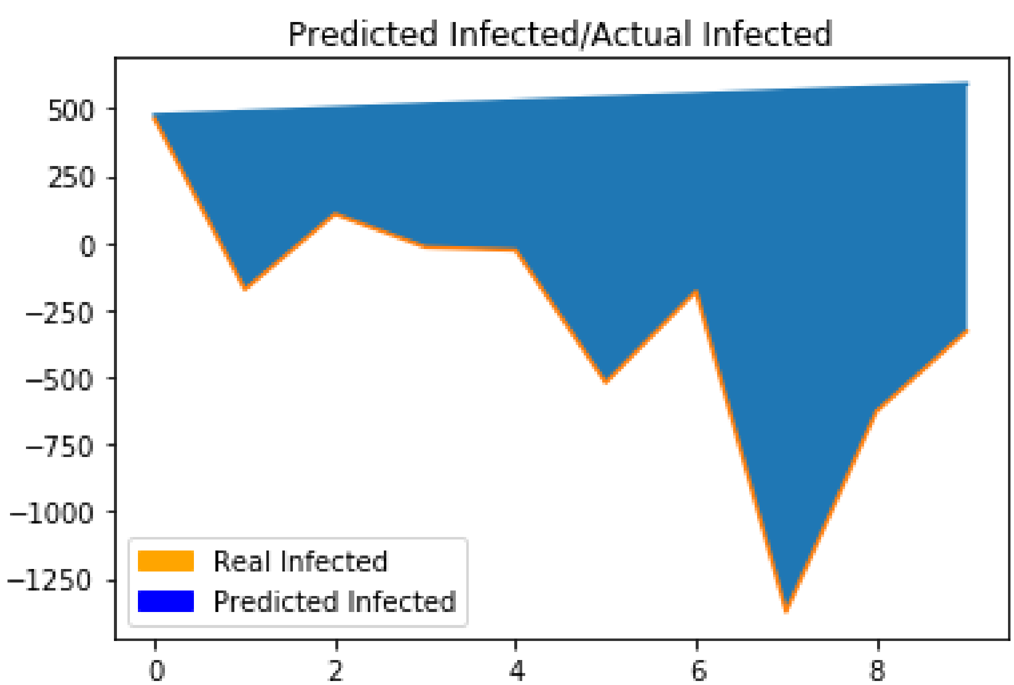
```
April 17:
[265004    461     84     13]
Predicted May 1
[265004.2934672133    474.4601104743     87.2119483867     13.7075094474]
Predicted May 2
[265004.5869347515    487.8058012893     90.5176780752     14.4356764986]
Predicted May 3
[265004.8804026148    501.0380452498     93.9163918636     15.1843255505]
Predicted May 4
[265005.173870803     514.15780689       97.4072993281     15.9532824931]
Predicted May 5
[265005.4673393163    527.1660425432    100.9896167649     16.7423746967]
Predicted May 6
[265005.7608081545    540.063700412     104.6625671333     17.5514309992]
Predicted May 7
[265006.0542773177    552.8517206375    108.4253799994     18.3802816939]
Predicted May 8
[265006.3477468059    565.5310353674    112.2772914792     19.2287585169]
Predicted May 9
[265006.6412166191    578.1025688242    116.2175441835     20.0966946347]
Predicted May 10
[265006.9346867572    590.5672373728    120.2453871624     20.9839246326]
Actual Results
m1 … m10:
[[265004.    461.     84.     13.]
 [264924.   -174.    418.     29.]
 [264973.    107.    172.     25.]
 [265110.    -16.    191.     23.]
 [265035.    -27.    175.     19.]
 [265046.   -520.    635.     10.]
 [265028.   -181.    271.     11.]
 [265007.  -1372.   1459.     11.]
 [265013.   -627.    701.     15.]
 [264979.   -329.    425.     18.]]
```

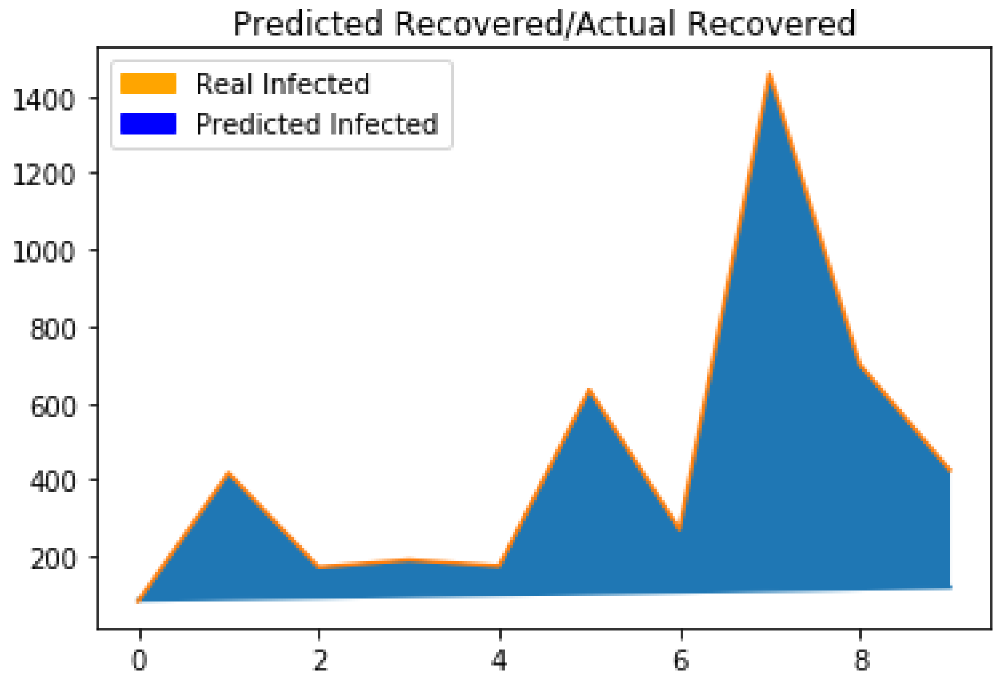
[172]:
```python
#Rearrange arrays for modeling
pi = np.array([pmay1[1], pmay2[1], pmay3[1], pmay4[1], pmay5[1], pmay6[1],
    pmay7[1], pmay8[1], pmay9[1], pmay10[1]])
print("Predicted Infected:")
print(pi)
pr = np.array([pmay1[2], pmay2[2], pmay3[2], pmay4[2], pmay5[2], pmay6[2],
    pmay7[2], pmay8[2], pmay9[2], pmay10[2]])
print("Predicted Recovered:")
print(pr)
pd = np.array([pmay1[3], pmay2[3], pmay3[3], pmay4[3], pmay5[3], pmay6[3],
    pmay7[3], pmay8[3], pmay9[3], pmay10[3]])
print("Predicted Deaths:")
print(pd)
ri = np.array([m[0][1], m[1][1], m[2][1], m[3][1], m[4][1], m[5][1], m[6][1],
    m[7][1], m[8][1], m[9][1]])
print("Real Infected:")
print(ri)
rr = np.array([m[0][2], m[1][2], m[2][2], m[3][2], m[4][2], m[5][2], m[6][2],
    m[7][2], m[8][2], m[9][2]])
print("Real Recovered:")
print(rr)
rd = np.array([m[0][3], m[1][3], m[2][3], m[3][3], m[4][3], m[5][3], m[6][3],
    m[7][3], m[8][3], m[9][3]])
print("Real Deaths:")
print(rd)
```

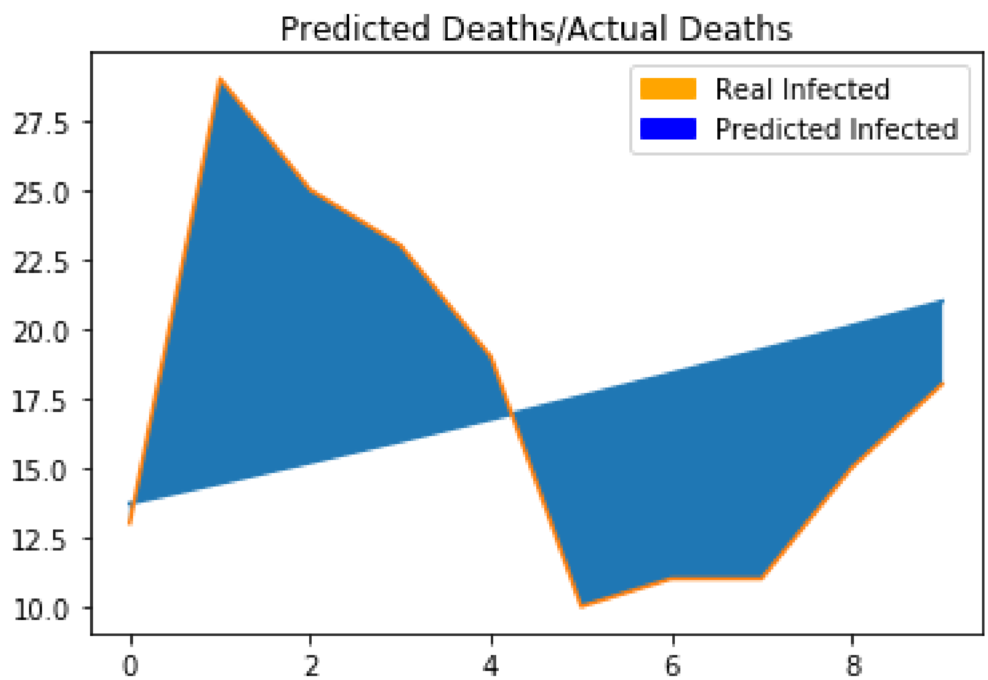
```
Predicted Infected:
[474.4601104743 487.8058012893 501.0380452498 514.15780689
 527.1660425432 540.063700412  552.8517206375 565.5310353674
 578.1025688242 590.5672373728]
Predicted Recovered:
[ 87.2119483867  90.5176780752  93.9163918636  97.4072993281
 100.9896167649 104.6625671333 108.4253799994 112.2772914792
 116.2175441835 120.2453871624]
Predicted Deaths:
[13.7075094474 14.4356764986 15.1843255505 15.9532824931 16.7423746967
 17.5514309992 18.3802816939 19.2287585169 20.0966946347 20.9839246326]
Real Infected:
[  461.  -174.   107.   -16.   -27.  -520.  -181. -1372.  -627.  -329.]
Real Recovered:
[  84.  418.  172.  191.  175.  635.  271. 1459.  701.  425.]
Real Deaths:
[13. 29. 25. 23. 19. 10. 11. 11. 15. 18.]
```

[176]:
```python
#Graph
import matplotlib.patches as mpatches
```

```
z = [0,1,2,3,4,5,6,7,8,9]
plt.plot(pi)
plt.plot(ri)
blue = mpatches.Patch(color='blue', label='Predicted Infected')
orange = mpatches.Patch(color='orange', label='Real Infected ')
plt.legend(handles=[orange, blue])
plt.fill_between(z, pi, ri)
plt.title('Predicted Infected/Actual Infected')
plt.show()
plt.plot(pr)
plt.plot(rr)
blue = mpatches.Patch(color='blue', label='Predicted Infected')
orange = mpatches.Patch(color='orange', label='Real Infected ')
plt.legend(handles=[orange, blue])
plt.fill_between(z, pr, rr)
plt.title('Predicted Recovered/Actual Recovered')
plt.show()
plt.plot(pd)
plt.plot(rd)
blue = mpatches.Patch(color='blue', label='Predicted Infected')
orange = mpatches.Patch(color='orange', label='Real Infected ')
plt.legend(handles=[orange, blue])
plt.fill_between(z, pd, rd)
plt.title('Predicted Deaths/Actual Deaths')
plt.show()
```







The graphs and results are much better the second time, however they are still pretty far off. I think that Japan's data is so screwed up that it is hard to find a predictive model based on prior data because the data itself is corrupt. And thats pretty much my final conclusion. 126 million citizens, with only 16000 confirmed cases and 825 deaths. Covid is supposed to be bad for the elderly, and Japan literally the oldest population in the world with 26% of the population over the age of 65. Yet no deaths. Maybe they are immune, or maybe they just aren't reporting, but I did my best.

```
[ ]:
```