MATH 370 - Coronavirus Project

In class, we discussed the following SIR model for the spread of a disease through a population divided into susceptible, infected, and removed categories:

$$
\begin{aligned}
S_{n+1} &= S_n - aS_nI_n \\
I_{n+1} &= I_n + aS_nI_n - rI_n \\
R_{n+1} &= R_n + rI_n,
\end{aligned}
$$

where a is the transmission coefficient and r is the removal rate. This model assumes a fixed total population size N such that for each day n we have $S_n + I_n + R_n = N$.

For this assignment, you will explore and extend this model for the latest coronavirus outbreak. First, for the original model above:

1. Choose a fixed population size N for which you would like to model the spread of the coronavirus over (US population, China population, world population, etc.), and an initial date to associate with $n = 0$.
2. Estimate r and a using real data on the length of infection and spread of the virus (provide citations for any figures you find here).
3. Obtain a numerical solution for your model from your initial date until the end of the semester. Describe what your model is predicting and assess the reasonableness of the prediction.
4. Separately adjust each initial condition and parameter of the model by 1% and rerun the simulation. Does your model appear sensitive to initial conditions and/or parameters?

Next, extend the above model to include at least one extra compartment or at least one extra interaction between compartments. Ideas include splitting the removed compartment into recovered and deceased, adding a quarantine compartment, adding an exposed compartment, adding the effects of reinfection, adding the effects of vaccination, etc. You may consult the robust literature on SIR models to assist with brainstorming.

1. Describe your extension and any assumptions you are making to justify the specific forms of the additional terms and/or equations in your new model. For any new parameters you introduce, estimate their value using real data.
2. Obtain a numerical solution for your new model from your initial date until the end of the semester. Describe what your model is predicting and contrast this prediction with your original model.
3. Find the equilibrium solutions for your model. Based on your numerical simulations, do any of these equilibrium solutions appear stable?
4. Separately adjust each new parameter of the model by 1% and rerun the simulation. Does your model appear sensitive to the additional parameters you introduced?

Your findings should be summarized in a typed report with attached results from Excel, Mathematica, etc. You may work individually or in groups of 2-3. This project will be due Thursday, February 20, 2020.