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STUDENT VERSION
Modeling Social Campaigns

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STATEMENT

The Ice bucket challenge was one of the most successful social media campaigns. What do you think made the ice bucket challenge so extremely successful? More generally, why do some campaigns become successful while some fail terribly? How can we characterize a successful campaign versus an unsuccessful campaign? How can we make an unsuccessful campaign into a successful one? What is your strategy?

To tackle these problems, we could elaborate the similarities between a social campaign and an infectious disease transmission by exploring a compartment model, Susceptible-Infected-Recovered (SIR) model, that is often used to describe how infectious disease propagates through a population. In an SIR model, the problem is formulated with a system of three nonlinear, first order differential equations where three compartments (S, I, and R) of the population are linked. The application of this model is not limited to epidemic modeling. It has been applied to describe malware propagation, viral marketing, and social networking.

The state variables are defined as: $S(t)$ is the number of susceptible individuals at time t, $I(t)$ is the number of infected individuals at time t, and $R(t)$ is the number of post-infective individuals removed from the population at time t. The basic governing equations with a constant population $P = S(t) + I(t) + R(t)$ can be written as:

$$\begin{aligned} S'(t) &= -\beta I(t)S(t)/P, & (1)\\ I'(t) &= \beta I(t)S(t)/P - \gamma I(t), & (2)\\ R'(t) &= \gamma I(t), & (3) \end{aligned}$$

where β is the contact rate between the infected and the susceptible compartments, and γ is the recovery rate which is the reciprocal of the mean recovery time, m. In this system, the rate of change in the susceptible class is non-positive and proportional to the product of the infected and the susceptible. The rate of change in the recovered class is non-negative and proportional to the infected class. Assuming that there is no change in the entire population P, i.e. $P' = (S(t)+I(t)+R(t))' = 0$. In the case that people in the recovered group are temporarily immune and return to the susceptible class, then the extra term νR should be considered in the right side of (1) and (3), where $1/\nu$ is an average length of time for an individual in the recovered class to rejoin to the susceptible group. See the Project 1 in Chapter 9 in [1].

In this study, we apply the SIR model to describe and predict a social campaign. The scenario of our interest is that a person nominates k people within his/her social media group and each nominee is expected to nominate k people within m days, as seen in the ice bucket challenge.

Consider the following questions:

Question 1. We first consider how to modify (1)-(3) to describe the given scenario of social campaign. What are the compartments in the social campaign scenario? How do you define or interpret the constants β and γ?

Question 2. Since the status of a social campaign is evaluated per day or per week, convert the system of differential equations (1)-(3) into a system of appropriate difference equations. What should be considered to discretize the differential equations? See [2] for details.

Question 3. How can we model a joining (quitting) process and integrate the process into the system of difference equations in Question (2)? Does the process follow any particular probability density distribution?

Question 4. What do you think is the major difference in the joining (quitting) process for distinguishing a successful campaign and an unsuccessful campaign? What is your strategy to lead a social campaign to a success?

REFERENCES

[1] Boyce, W. E and DePrima, R. C and Meade, D. B. 2017. *Elementary Differential Equations and Boundary Value Problems*. Wiley Global Education, 2017.

[2] Allen, L. J. S. *Some Discrete-Time SI, SIR, and SIS Epidemic Models*. Elsevier Science Inc., Mathematical Biosciences, 1994.