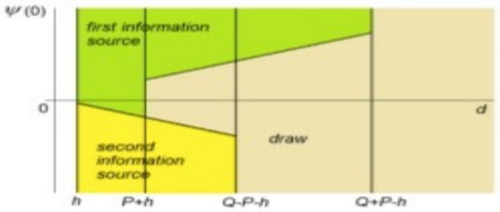
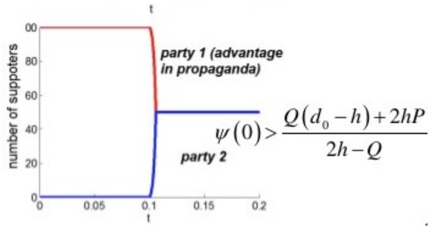
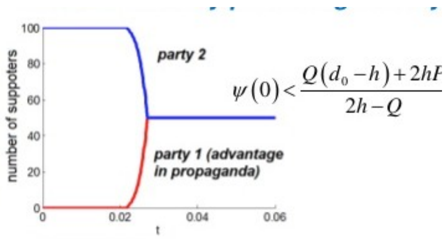






The Effect of Social Polarization on the Outcome of Information Battles

MATH MODELING FINAL REPORT

MATH 485 Instructor: Dr. Ildar Gabitov

Mentor: Jonathan. David Taylor

Member: Kaitong You

Rongrong Cao

Steven Jiang

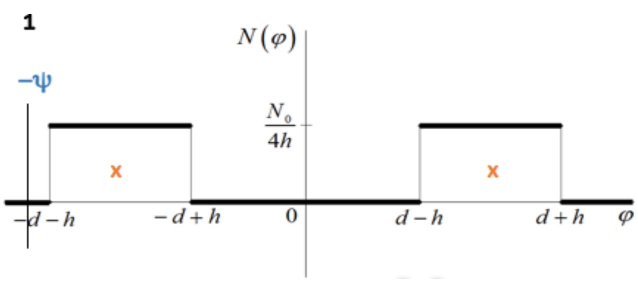
1. Abstract

This project is motivated by the set of issues related to the effect of political polarization on the propaganda battle. With the assumption that people are struggling between two party X and party Y with a fixed total population, observing the shift of the people between two parties. The goal of our project was to analyze the behavior of whole dynamics systems and the outcome of the propaganda war based on the influence of different factors based on the model of "Rashevsky Neurological Scheme".

After learning the background of propaganda battle and the effect of political polarization, we could tell the outcome of the propaganda battle by using the distribution curve basing on Rashevsky's neurological scheme. Observing the function giving by the Rashevsky's neurological scheme carefully, we noticed that there are several factors in this function will affect the outcome of our model. What's more, the distribution curve we used as tool also gets affected when the value of d (Degree of polarization of society) and the value of h (Measure of consolidation of individuals within each group) change. In order to analyze how do those factors control the result of the information warfare, we set all those factors as parameters in our coding, then choose only one parameter where keeping the rest of the parameters fixed, we change the value of selected parameter and test the relationship between this specific parameter and the wined party of the propaganda battle. We repeat this way to test all the parameters to figure out the how those parameters will influence the process of rumor battle.

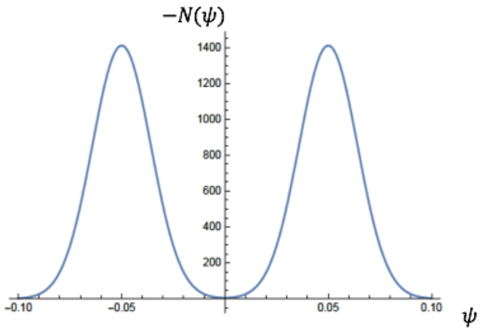
2. Introduction

Introduced by the paper we are working on, we rely on the distribution curve as following,



Graph #1

However, this kind of distribution curve is the ideal condition, which means, in the real life, we could not get the distribution like this curve displays. So, we use a more realistic distribution curve to assist us to analyze the outcome of the propaganda battle, the Bi-Modal Gaussian Distribution Curve. Gaussian distribution curve also is named as normal distribution curve, which is a bell-shape curve and symmetrically distributed around the mean. Since we analyze two different groups, we need to consider the bimodal (two-peak) to describe the distribution curve. Here, the d (Degree of polarization of society) in the bimodal distribution curve is the mean value, and the h (Measure of consolidation of individuals within each group) in the bimodal distribution curve is the variance.



Graph #2

3. Analysis Method

Supporting there are two parties—party X and Part Y, and each party has its two method to spread the party information—the interpersonal communication and the media.

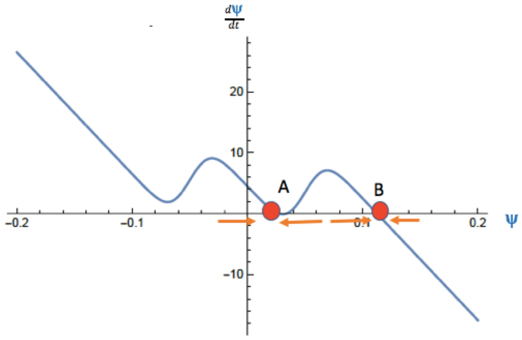
Based on the Rashevsky's neurological scheme:

$$\frac{d\psi}{dt} = A\alpha\left[C\left(2\int_{-\psi(t)}^{\infty} N(\varphi)d\,\varphi - N_0\right) + b_1 - b_2\right] - a\psi$$

- C: importance of interpersonal communication
- b_1, b_2: intensity of the media from each party ($b_1 > b_2$)
- $A\alpha$: susceptibility of individuals to stimuli
- a: decay rate

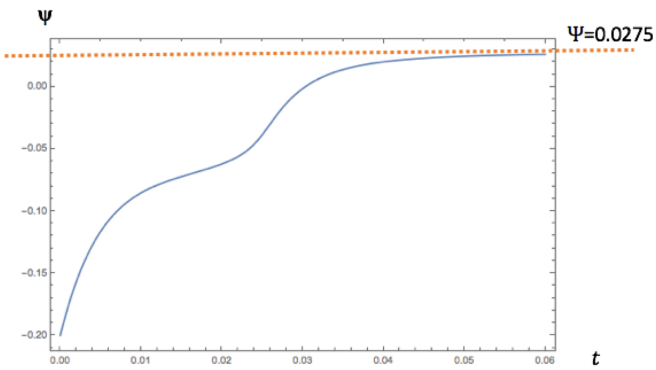
We analyze each parameter use the following way:

- Step 1: Set the initial condition and get the relative Bimodal Gaussian Distribution Curve.
- Step 2: Solve the differential equation to find the equilibrium(s) and get the stable point(s) after analyzing.



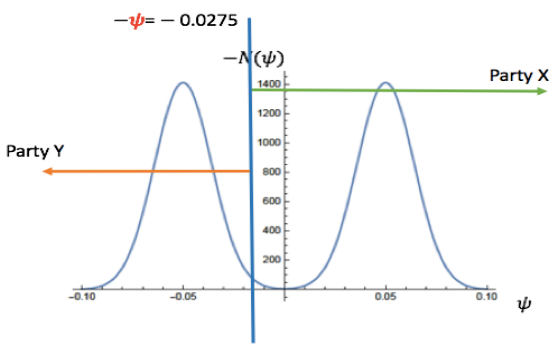
Graph #3

- Step 3: Consider the relationship between the values of ψ and the time. We could find all the value of ψ will approach the fixed value—the stable point during a specific time period.



Graph #4

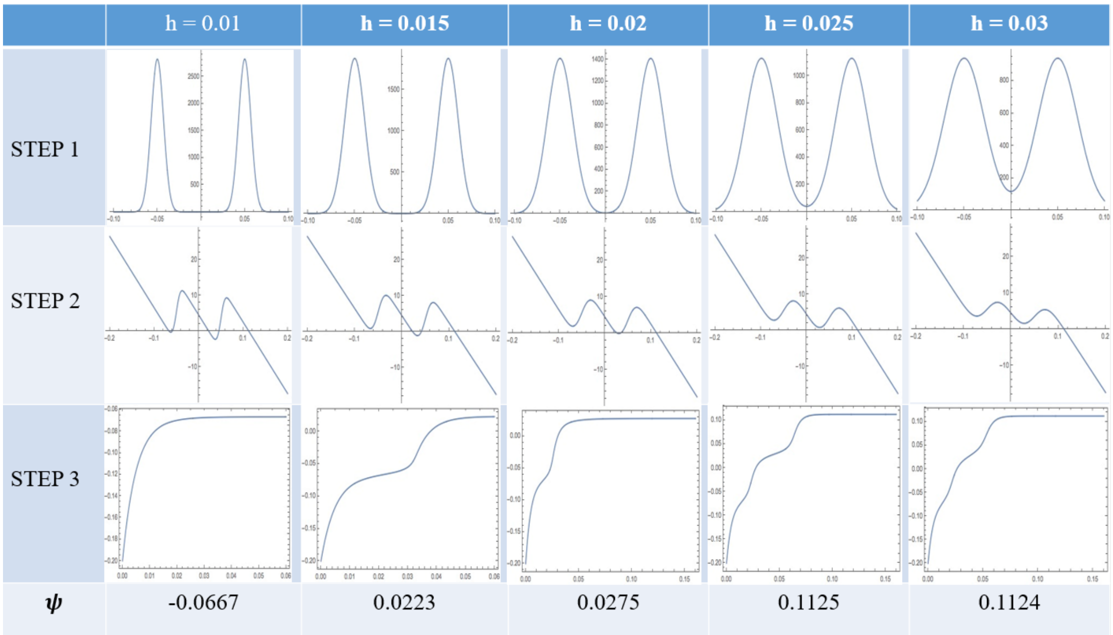
- Step 4: The value of ψ will be told by the step 3, so back to the bimodal Gaussian distribution curve giving in the step 1, we could find the position of psi and then get the total number of people who support Party X. finally, we could compare the total number of each party to figure out which party will win.



Graph #5

4. Analysis of Model

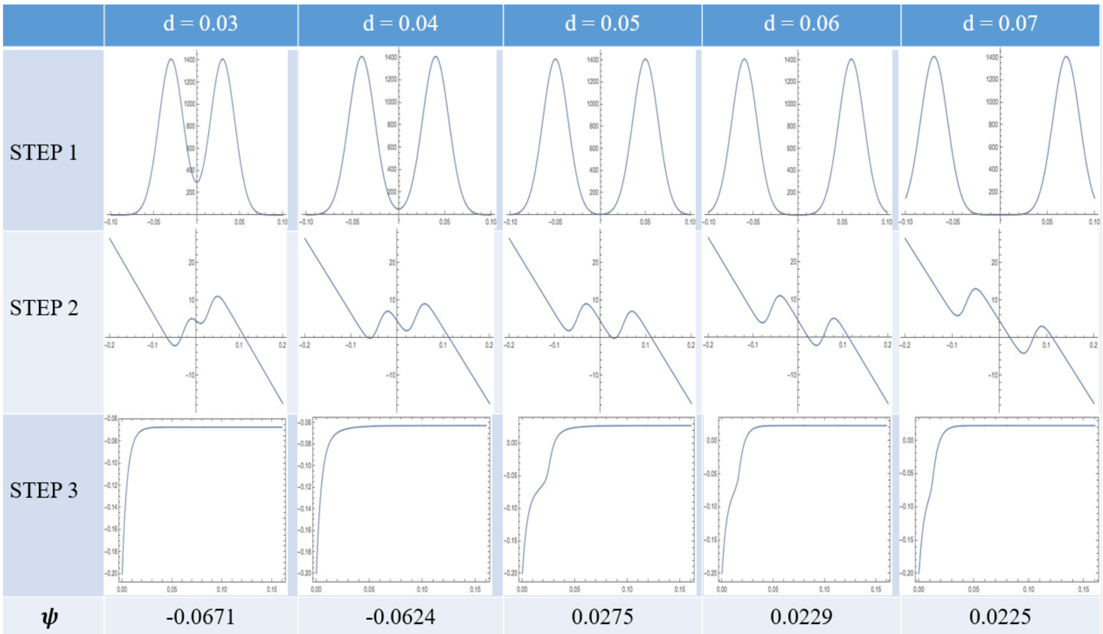
Although we changed the distribution of population to bimodal Gaussian Distribution, we still could change the value of standard derivation and mean of the distribution to alter the distribution of whole population. First, we changed the values of h which were the standard derivations for each modal. As we increased h from 0.02 to 0.03, the standard derivation for each modal became smaller which meant the distribution of people was less centralized. The new ψ value got in this particular case was 0.1. Comparing to the original ψ = 0.025, we could see that if we increased the value of h, the final ψ would become larger. From the distribution graph, we knew that X party would win with large number of supporters. Two values were not enough for finding a scientific result. So, when we plugged more values for h, we found out that as we increased the value for h, the total number of stable points was decreasing when all other values were kept constant.



Graph #6

When there were three stable point, Party Y will win with a small advantage. When there were two stable points, it would change to party X win with a small advantage. However, when there was only one stable point, party X would win with a large number of supporters. From the graph for $\frac{d\Psi}{dt}$ vs time, the amplitudes for both period were decreasing when we defined the graph for $t < 0$ as first period and $t > 0$ as second period. Also, the value for last stable point was always the same. From all the information above, we found out that getting larger standard derivation value of the distribution could help party X to win the battle with larger number of supporters.

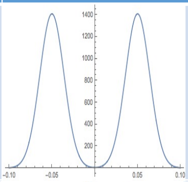
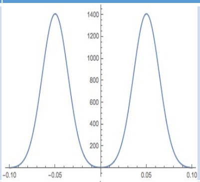
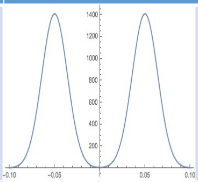
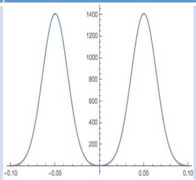
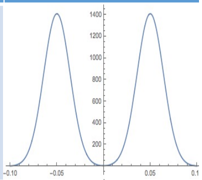
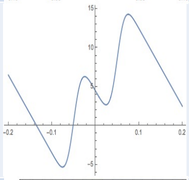
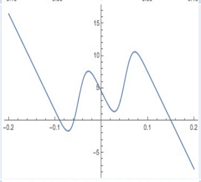
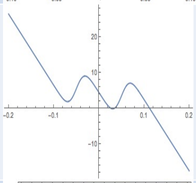
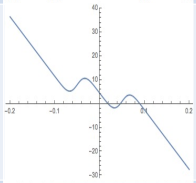
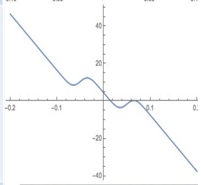
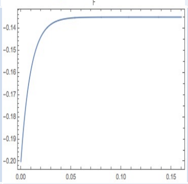
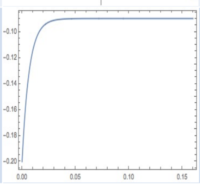
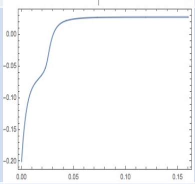
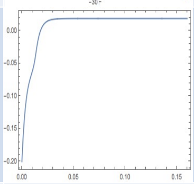
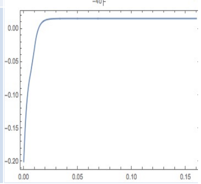
Now, we changed the value of d which was the mean value for each modal of the distribution. First, we choose two values, original value d = 0.05, and changed value to 0.07. However, the final ψ values for this two particularly number did not change a lot. Nevertheless, the time to achieve the same final ψ value became smaller. And in both cases, X party would win with a small advantage.



Graph #7

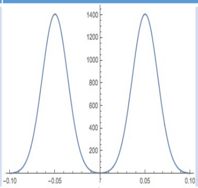
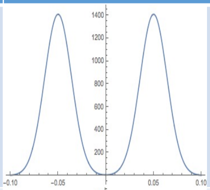
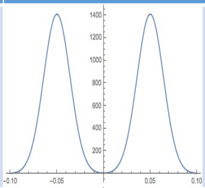
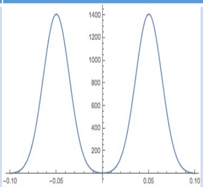
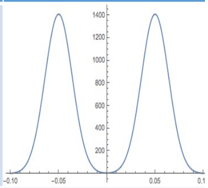
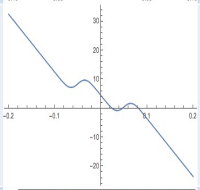
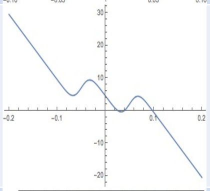
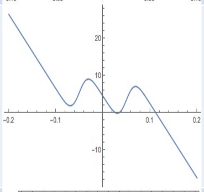
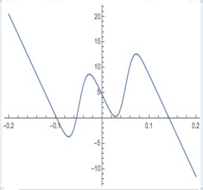
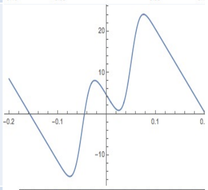
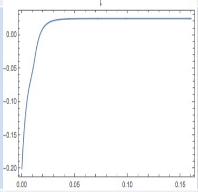
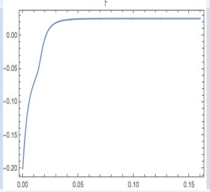
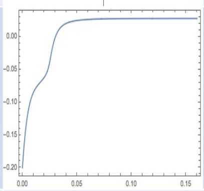
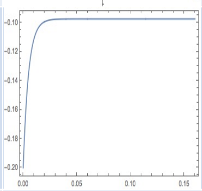
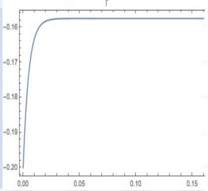
When we plugged more values for d, we found out that the value of first period was moving upward, and the second period was moving downward when the amplitude for both period did not change. If the first stable point was in the first period, then party Y would win. If the first stable point was in second period, then party X would win. So, changing the value of d could not help party X to win with a large number of supporters, but it would change the final result whether party X or Y would win, also it would affect the time for both party to get the final result.

After increasing the value of the parameter "a" which means the decay rate from 200 to 150 and keeping other parameters fixed, we found there exists two stable points in our graph of the main function. Then, we analyzed these two stable points separately. We compared the graph of the value of the first stable point with the original case, it was evident that both graphs started with the same initial value. But, it took less time for ψ to get to the first stable point. So, the value of ψ is relatively small which approached -0.092. When we discussed the second stable point, the ψ value needs more time to get to the second stable point. As a result, the value of ψ at the second stable point is larger than the first one. Its value approached 0.15 as we observed. After we analyzed this special case, we picked four more values for the decay rate to further research the behavior of the whole dynamic system and the outcome of the propaganda battle. We found that the graph of our main function becomes more stable when we increased the value of “a” gradually. From the graph, we concluded that if the first stable point is in the first period, the value of ψ is increasing. Under this case, party Y will win the battle. On the other hand, if the first stable point is in the second period, the value of ψ is decreasing and party X will win the battle. Our final conclusion based on the decay rate is in order to help X party win the battle with large amounts of supporters, it is essential to keep the decay rate small.

	a = 100	a = 150	a = 200	a = 250	a = 300
STEP 1					
STEP 2					
STEP 3					
ψ	-0.135	-0.0897	0.0275	0.019	0.0154

Graph #8

When we increased the value of the parameter “c” which means the importance of interpersonal communication from 0.06 to 0.08and keep other parameters fixed, the graph of our function gave us two new stable points. The value of the first stable point was around -0.096 and the value of the second stable point approached 0.14. The reason for getting these two different value was mentioned before. We chose 0.04, 0.05, 0.06, 0.08 and 0.12 as our observed “c” values. As we observed, the amplitude of the graph of the function becomes more stable as the value of “c” increasing. If the first stable point is in the first period, the value of ψ is decreasing and party Y will win; if the first stable point is in the second period, the value of ψ is increasing and party X will win. We also found the value of the second stable point is increasing as the value of “c” increasing. Our conclusion is in order to help X party X win the battle with a large amount of supporter we should strengthen the importance of interpersonal communication.

	c = 0.04	c = 0.05	c = 0.06	c = 0.08	c = 0.12
STEP 1					
STEP 2					
STEP 3					
ψ	0.0247	0.0257	0.0275	-0.0975	-0.1575

Graph #9

5. Conclusions and Future Perspectives

Based on our findings, we think our research can be broadly used on the various kinds of information battle, including election campaign, commercial propaganda, and science popularization. It will be really hard to control the population distribution since it will affect all the people in the society, but it is an effective way to have the high standard derivation. In order to help one of the parties win the battle, if we can keep the decay rate of the population low which means attracting more people to pay attention to the information and maximize the interpersonal communication which can help the information spread in a fast speed, the final outcome of the information battle will be more controllable and reasonable.

Reference

Mikhailov, A.P. & Petrov, Alexander & Proncheva, Olga. (2017). Modeling the Effect of Political Polarization on the Outcome of Propaganda Battle. COMPUTATIONAL MATHEMATICS AND INFORMATION TECHNOLOGIES. 1. 65-81. 10.23947/2587-8999-2017-1-1-65-81;

M. Nekovee, Y. Moreno, G. Bianconi, M. Marsili. Theory of Rumor Spreading in Complex Social Networks // Physica A. 2007. 374. pp. 457- 470

Yanagizawa-Drott D. Propaganda and Conflict: Evidence from the Rwandan Genocide // The Quarterly Journal of Economics.2014 129(4). 1947-1994. Doi: 10.1093/qje/qju020

Guanghua Chen, Huizhang Shen, Teng Ye, Guangming Chen, and Naphtali Kerr, A Kinetic Model f or the Spread of Rumor in Emergencies, Hindawi Publishing Corporation, Discrete Dynamics in Nature and Society, Volume 2013, Article ID 605854, 8 pages, http://dx.doi.org/10.1155/2013/605854

Mikhailov A. P., Petrov A. P., Proncheva O. G., Marevtseva N. A., Mathematical Modeling of Information Warfare in a Society, Mediterranean Journal of Social Sciences, MCSER Publishing, Rome-Italy, Vol 6 No 5 S2, September 2015, Doi:10.5901/mjss.2015.v6n5s2p27.