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Modeling Bursty Temporal Pattern of Rumors

Sejeong Kwon, Meeyoung Cha
Graduate School of Culture Technology
Korea Advanced Institute of Science and Technology, Republic of Korea
{gsj1029, meeyoungcha}@kaist.ac.kr

Abstract

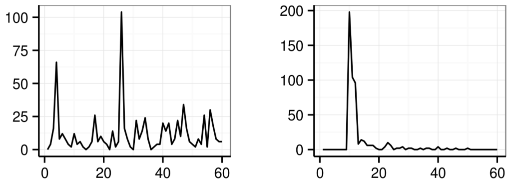
Online social networks enable fast and wide diffusion of rumors, which could be potential threats to the society. Understanding the rumor spreading mechanism is therefore essential. This demo presents an agent-patternbased model that can explain the spiky temporal diffusion pattern of rumors. The demo platform provides an interface allowing users to check a wide set of parameters contribute to the characteristic temporal pattern of rumors.

Introduction

Diffusion is an important part of social media culture. Rapid and wide diffusion demonstrates the power of the medium and allows users to tune into topics that are popular worldwide or in a specific region. This phenomenon has positive and negative functions at the same time. Utilizing online social media as an efficient way of viral marketing is one of the positive functions. On the other hand, mass propagation of mis-information can cause tremendous damage to a community. A prominent example is rumors on H1N1. In Twitter, millions of users saw mis-information that eating pork can propagate the virus. This wrong information introduced a network-wide panic.

Unlike traditional mass media, the new social media have no process of verification. Consequently, unverified information may have the same viral potential as verified information. Rumors are of particular interest because they exhibit diffusion patterns that are different from non-rumors. On Twitter, rumors are known to (1) spread through low degree users (2) contain certain linguistic features such as negation and speculation and (3) appear repeatedly over time with more spiky temporal shape (Kwon et al. 2013). One of discriminative features of rumor spreading is that rumor's temporal shape has multiple peaks over time and a longer life span compared to non-rumors. Figure 1 shows diffusion pattern of a example of rumor and non-rumor event in Twitter.

In this demo, we try to explain why rumors have repetitive and spiky temporal shape over time. We propose an agent-based model with parameters that describe reliability and diffusion characteristics of a given piece of information. By tuning the parameters, we can simulate various shapes of time series and generate rumor-like spreading patterns.



(a) Rumor (b) Non-rumor

Figure 1: Temporal pattern of a representative rumor and non-rumor event, with the x-axis as days and the y-axis as the number of tweets.

Modeling Temporal Pattern

External Shock and Exclusivity

The bursty temporal pattern has been found as a prominent feature for rumor classification, which needs to be understood better (Kwon et al. 2013). While there may be a number of reasons that contribute to this pattern (e.g., opportunistic activities of rumor mongers), here we focus on content value and its impact on the diffusion pattern. We introduce a concept of external shock and exclusivity as below.

1. External shock: Regularly, a certain number of people are exposed to a given piece of information. In our model, we assume external shocks last only during the simulation period, which considers a relatively short time span such as several months. In our model, we assume that external shock is lasting to end of simulation because we consider only short period of 1-2 months.
2. Exclusivity: This concept describes the informational value of a given piece of information, similar to the basic reproduction number in epidemiological models. Each content has its own exclusivity value, which decays over time at different rates. In case of a rumor, its decaying rate is smaller than non-rumors, indicating a much longer life time than non-rumor. This is because rumor spreadings are localized in the network (e.g., rarely mentioned by mass media), it could be perceived as noteworthy and

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informational to some users although it spread widely in social media.

Exclusivity is a global value defined between 0 and 1, where 1 represents the highest level of informational value and 0 means otherwise. Upon receiving a content, a user will decide to propagate it further in the network if the exclusivity value of the content exceeds one's predefined threshold. We assume users are assigned with thresholds between 0 and 1 following a uniform distribution (this can be tuned to other probability distributions). Through external shocks, new content gets exposed to a random set of seeds in social media periodically(i.e., random periodic seeding in online media).

Spreading Mechanism

Our model is based on an agent-based model. Followings are the specifications about agent and parameter setting.

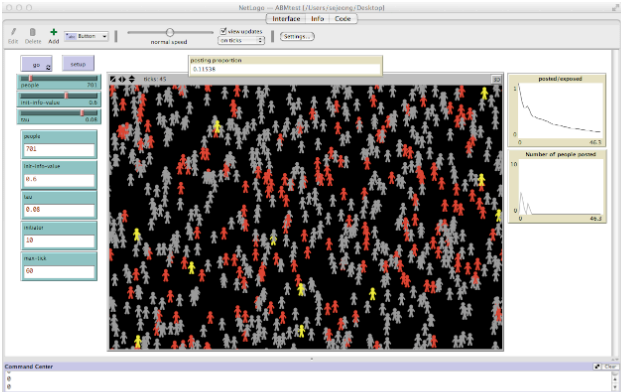
- N: Total population. Any integer > 0
- t: time step for agent-based model
- Exclusivity ($Ie^{-\delta t}$)
  - I: Initial value of exclusivity. it is different by types of information and related content in the range of 0-1.
  - δ: Decreasing rate. Value for rumor is smaller than other types of information.
- External Shock (S when $t = kP$ for $k \in \{1, 2, \dots\}$ and 0 for otherwise)
  - S: Number of users who gained a piece of information from out of online media. Any integer > 0
  - P: Any integer > 0
- Individual (Agent)
  - Status: non-exposed, exposed and posted
  - Threshold: Assigned from 0 to 1 with uniform distribution, randomly.

At the initial step ($t = 1$), we set N, I, δ, S and P. For each agent, threshold will be assigned automatically and status is non-exposed by default.

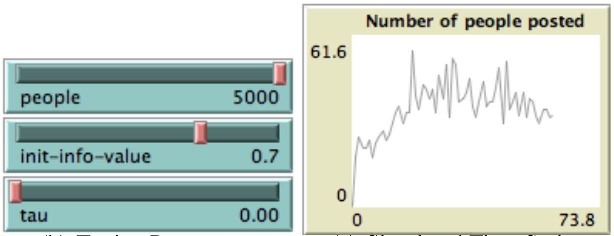
For each time step, the model runs 4 processes. First, agents change their spatial position randomly. Second, a subset of agents are set as 'exposed' (i.e., random periodic seeding through external shock). Third, the exposed agents either propagates the information or ignores it based on their thresholds. Lastly, agents who 'post' for the first time will cause a subset of the nearby located agents as 'exposed'. These processes repeat.

Demo description

The snapshots in Figure 2 shows the user interface, functionality and tuning availability of the demo platform. The platform is constructed by LetLogo (Tisue and Wilensky 2004), a popular agent-based modeling tool. With assistance of this tool, we can illustrate every step of the diffusion process. The platform allows users to adjust parameters N, I, δ, S and P, which are described in the earlier section. With this demo, user can see examine how changes in the parameter values such as exclusivity and the size of network cause different temporal bursty pattern of information diffusion.



(a) Interface (Agent-based Model via NetLogo)


people 5000
init-info-value 0.7
tau 0.00

(b) Tuning Parameters (c) Simulated Time Series

Figure 2: Demo snapshot of the user interface, parameter tuning, and a test result. The platform allows control for a wider set of parameters, which are omitted for page limitation.

Conclusion

This demo presents an agent-based model that can explain why the spread of misinformation has bursty temporal pattern. Based on existing social and psychological theories about rumor spreading, we modeled several key factors that are related to interpersonal interactions. Through this demo, we show that the varying decaying rates of informational value (defined as exclusivity in this work) may be a major cause of the characteristic temporal pattern in rumor spreading. [1]

References

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[1] The presenter of this demo will be first author, who developed main hypothesis and built the simulation program.