Characterizing and Modeling the Dynamics of Cyber Movements

Wang Xiao
The State Key Laboratory of Management and Control for Complex Systems
Institute of Automation, Chinese Academy of Sciences
Beijing, China
kara0807@126.com

Zeng Ke
School of Electronics and Communication Technology
Xi'an Jiaotong University
Xi'an, China
Ke.zeng@live.cn

Abstract—**The availability of data from online social media has recently created unprecedented opportunities to explore human and social phenomena on a global scale. In this paper, we provide a quantitive, large scale, temporal analysis of the dynamics of online collective behavior in a specific cyber movement on Tianya.cn, and point out that particle swarm theory can be used to model and simulate the variable interactions between cyber movement participants. This model updates each participant's position in accordance with two factors: historical experience accumulation and social interaction, and highlighting their importance in driving the dynamics of cyber movements.**

Keywords—Dynamics of cyber movement; particle swarm theory; social phenomena; collective behavior

I. INTRODUCTION

Now days, it becomes more and more popular for people to use network to show their opinions about problems, issues and hot topics in our physical world. Therefore, cyber space has become an actual parallel world to our physical world. This perspective provides new views for us to understand cyber organizational behaviors and cyber movements [1, 2, 3, 4].

In terms of specific online or offline incidents, people use network as a platform to show, to communicate and to voice their opinions, and get clustered to form cyber movements [5]. Therefore, to some extent, cyber movements are the movements induced by online means or methods and can be strengthened by both online and offline behaviors. The most important characteristic of cyber movement is that it causes collective behavior both offline and online, while social movements only cause offline collective behavior. Generally speaking, cyber movements are usually caused by online hot topics, real social issues or special reports of social media. In terms of one specific hot topic, cyber who get interested rapidly get together to discuss and communicate with each other, and form organizational collective behaviors. For example, the increasing of price of gasoline would cause collective resistant behavior of people who have vehicles. The organizational collective behavior of cyber movement is able to help rapidly transmit information, diffuse influences and bring great social and economic affects. Lately, the emergence, growth and dynamics of cyber movements have drawn great attentions of scholars from mathematics, biology, economics, computer science [3-6], to name but a few.

Earlier researches use sociological approaches to study cyber movements, and lay great attention on the background of movement participants, which is not very appropriate for cyber movement as most online users use false information to register. Paper [5] points out that artificial society modeling method can be used to analyze the dynamics of a cyber-movement based on real social media data. Inspired by this perspective, we pay our attention to the modeling of the dynamics of cyber movement. By analyzing the participants' historical experience as well as the interaction between them, we model the dynamics of a cyber-movement based on particle swarm theory.

After defining the characteristics of cyber movements and analyzing the dynamics in Section 2, we describe how to use particle swarm theory to model the dynamics of cyber movement in Section3, and demonstrate its usage on real social media data from Tianya.cn in Section 4.

II. CHARACTERING THE DYNAMICS OF CYBER MOVEMENTS

In the past few years, cyber movements enabled by social networks sites(SNS) and social media have shown their formidable power to impact our physical world, for example, the Iran riot [7], the human flesh searching in China[8], to name but a few. By analyzing those cyber movements, we find that the general dynamics of cyber movements have the following features.

- The presenting way of information about the event is able to affect the growth and change of cyber movements.
- Participants keep moving on Internet to search information about the event and keep interacting with each other.
- As more and more online users become participants of the cyber movement, there are also participants constantly drop out.
- Typical star topological structures and power law distribution.

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Although single participant of a cyber-movement doesn't clearly show any organizational sign, the whole group always develops in a well-organized way. Besides, as a result of opinion conflicts, the movement may split into several sub-movements. In order to get more attention from other online users, the participants of each sub-movement will produce furious quarrels and discussions.

III. MODELING OF THE DYNAMICS OF CYBER MOVEMENTS

On one hand, network is a platform for communication, especially with the advances of social networks sites and social media; on the other hand, network is much more like a show-space for online users. Online users use network to show, to share their opinions, interests, histories and everything they want people to know about them. Besides, network is also used to show off, to present, and to express personalities and experience.

Cyber movement is full of complexities and uncertainties, hence it is hard to be described and simulated by traditional modeling methods. In order to solve the complex society modeling issue, paper [5] points out that multi-agent modeling method can be used to model the dynamics of cyber movements. Therefore, we model the dynamics of cyber movement based on particle swarm theory which is inspired by collaborative behavior of social creatures.

A. Particle Swarm Theory

Particle swarm theory [9, 11, 12] is inspired by self-organized, collective, heuristic behavior of social creatures, and points out that although single natural creature doesn't show any intelligent features; the entire group always works in a clearly well-organized way. For example, bee nesting, bird foraging. In another word, despite of single creature only can do simple works; the entire group has the ability to deal with complex, large scale problems. Therefore, particle swarm theory provides an efficient distributed solution for problems without global view and central control.

Particle swarm theory is originally used to simulate the bird foraging process. Birds constantly adjust their velocity and direction to find food in according to two factors: its own distance to food and their neighbors' distance to food, which means the dynamics of birds foraging are influence by both their historical experience and the social influence nearby. The dynamics of a single bird in particle swarm theory is described by two equations as (1) and (2) show.

$$V_i^{t+1} = \omega \cdot V_i^t + c_1 \cdot rand() \cdot (P_i - X_i^t) + c_2 \cdot rand() \cdot (P_1 - X_i^t) \quad (1)$$

$$X_i^{t+1} = X_i^t + V_i^{t+1} \quad (2)$$

Equation (1) is used to update the velocity of particles and (2) is used to update the position of particles. P_i represents the historical best position of bird *i*, P_l represents the best position of *i's* neighbor *l*. c_1 and c_2 respectively show the impact power of historical experience and social influence to bird *i*. ω is the inertia factor which means that the velocity before has an impact on the current velocity and t means the times of iteration.

B. Modeling Based on Particle Swarm Theory

In this paper, we treat the cyber space as the reflection of online users' opinion space, and treat cyber movement's participants as constantly moving particles in this opinion space. Thus, cyber movement participants can be seen as constantly moving particles who want to find the best suitable position for their opinions and personality. This modeling flow based on particle swarm theory has four steps.

- First, we use real social media data to initialize the original velocity and position of cyber-movement participants;
- Second, we choose a fitness function to decide whether the position of a participant is good or not;
- Third, update everyone's velocity and position in accordance with equation (1) and (2);
- Last but not the least, we setup a terminating condition; if the condition is not satisfied, repeat step (1), (2) and (3), otherwise, output the final results.

Figure 1 shows the modeling process of cyber movement based on particle swarm theory.

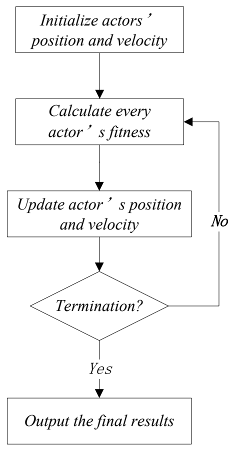

Fig. 1. The modeling process based on particle swarm theory

IV. CASE ANALYSIS: DYNAMICS OF "A BLOG WAR BETWEEN ZHAO WENZHUO AND ZHEN ZIDAN"

We take "a blog war between Zhao Wenzhuo and Zhen Zidan" as a case to analyze and study the dynamics of the collective behaviors of cyber movement organizations. This movement is a response of cyber to the conflicts between two celebrities: Zhen Zidan and Zhao Wenzhuo, and its purpose is to argue which one of them is more trustworthy. During the blog war, the participation of other celebrities, such as Shu Qi, Feng Xiaogang and Du Wenze, greatly motivated the enthusiasm of cyber participants and promoted the dynamical evolution of cyber movement organizations. At the same time, one related blog attracted more than 50,000 users' attention and created more than 800,000 messages.

A. Time Varied Social Networks

We assumed that if participant A replies or reposts a message of participant B, then a connection from A pointed to B is constructed. We analyzed the connections among participants, and constructed a social network in accordance with their connections. As cyber movements are under rapidly changing situations, we assumed that if a participant stopped publishing messages for a certain period of time, then s/he quit from the cyber movement; and s/he joined the movement again once he or she started to publish messages, which means a user becomes a participant as soon as s/he starts publishing messages below the topic-related blogs. The time varied social network of participants in this CMO from 20 Mar to 25 March is as figure 2 shows.

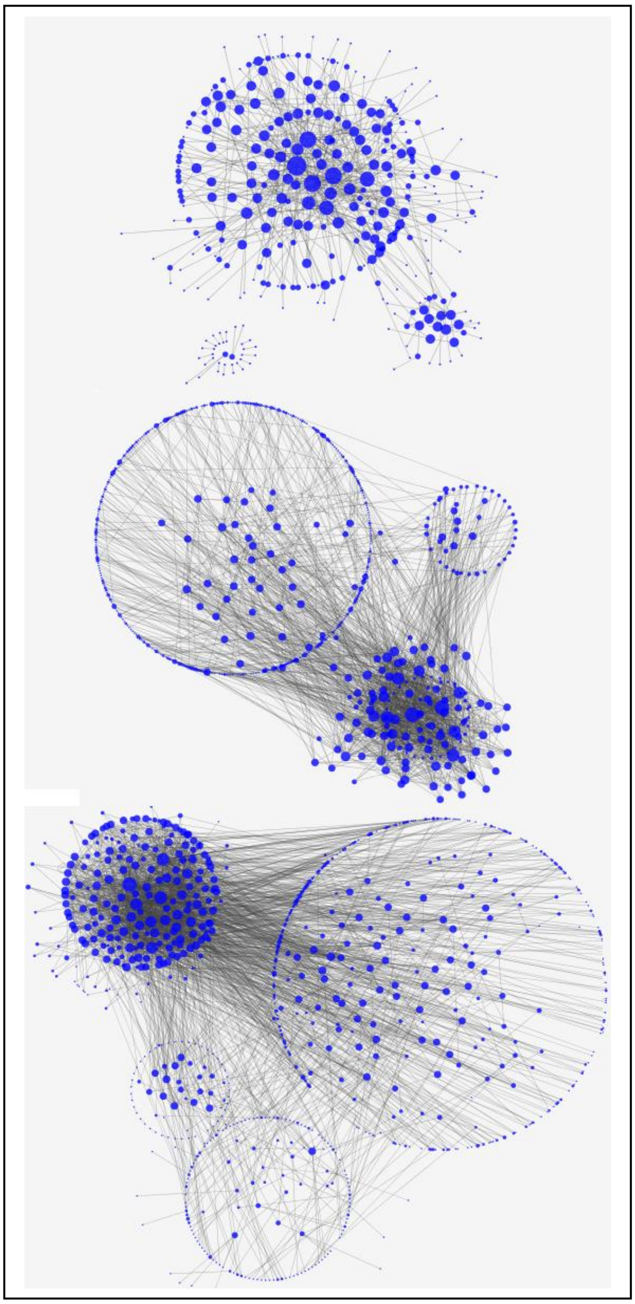

Fig. 2. The time varied social network of participants from 20-Mar to 25-Mar to 30-Mar

In figure 2, participants are represented by blue nodes, and the lines between each pair of them mean that there is at least one interaction at that day. From the figure above we can see, as time passing, the interactions between some nodes become tenser and tenser. It is because as more and more information and details of the event are presented on Internet, participants become more and more clear about their standpoint, and are all trying to find a best position to represent the ground that they are holding. Besides, in a global view, the nodes with high degrees in this figure are preferred to organize in horizontal distribution rather than in hierarchical distribution.

B. Modeling of the dynamics of cyber movement

Figure 2 shows that as time going on, the social interaction between each participants becomes denser and denser, and can form clearly clusters. In order to accurately model the dynamics of online collective behavior, we constructed a social matrix in accordance with the interaction between each participants. For sub-CMO(a) at time t, if participant i replied or reposted j's message for at least one time, then we set $m_{i,j}(a,t) = 1$, otherwise $m_{i,j}(a,t) = 0$, the social matrix is as formula 3 shows.

$$M(a,t) = \begin{matrix} m_{0,0}(a,t) & m_{0,1}(a,t) & \ldots\ldots & m_{0,n}(a,t) \\ m_{1,0}(a,t) & m_{1,1}(a,t) & \ldots\ldots & m_{1,n}(a,t) \\ \ldots\ldots & \ldots\ldots & \ldots\ldots & \ldots\ldots \\ m_{n,0}(a,t) & m_{n,1}(a,t) & \ldots\ldots & m_{n,n}(a,t) \end{matrix} \tag{3}$$

We initialized the position of each participant in according to *M(a,0)*, randomly initialized their velocity, and calculated each participant's fitness in line with formula (4). From formula (4) we can see that, the fitness of participant i is decided by the social connection s/he has. Even the number of messages that published by participants are very important at prompting the dynamics of CMOs, however, self-talking behavior does not help improve the social network of CMO participants. Therefore, we only take the interaction among participants into consideration. The modeling results of the clustering process of participants based on particle swarm theory as figure 4 shows.

$$fit_i(a,t) = \sum_{j=0}^{n} m_{i,j}(a,t) \Big/ \sum_{i=0}^{n}\sum_{j=0}^{n} m_{i,j}(a,t) \tag{4}$$

Before the emergence of specific events, users randomly surf on the internet as figure 3(a) shows. The emergence of event stimulate the appearance of implicit characteristics of users, those who get interested start posting messages and become participants. At the same time, participants with same opinions get closer and closer as 3(b, c) show, to make their voice larger and larger in order to achieve their goals. Besides, once the goals are achieved, participants get dismissed and turn to the state in figure 3(a) shows.

light on the importance of social influence between online users.

However, the findings in this paper are limited by the fact that we are not capturing the full range of social media data: users had a lot of accesses to other sources we do not consider that might have also influenced their behaviors. Further investigations should consider getting all kinds of related data. Besides, future research should also consider whether the finding in this paper is adaptive to other cyber movements.

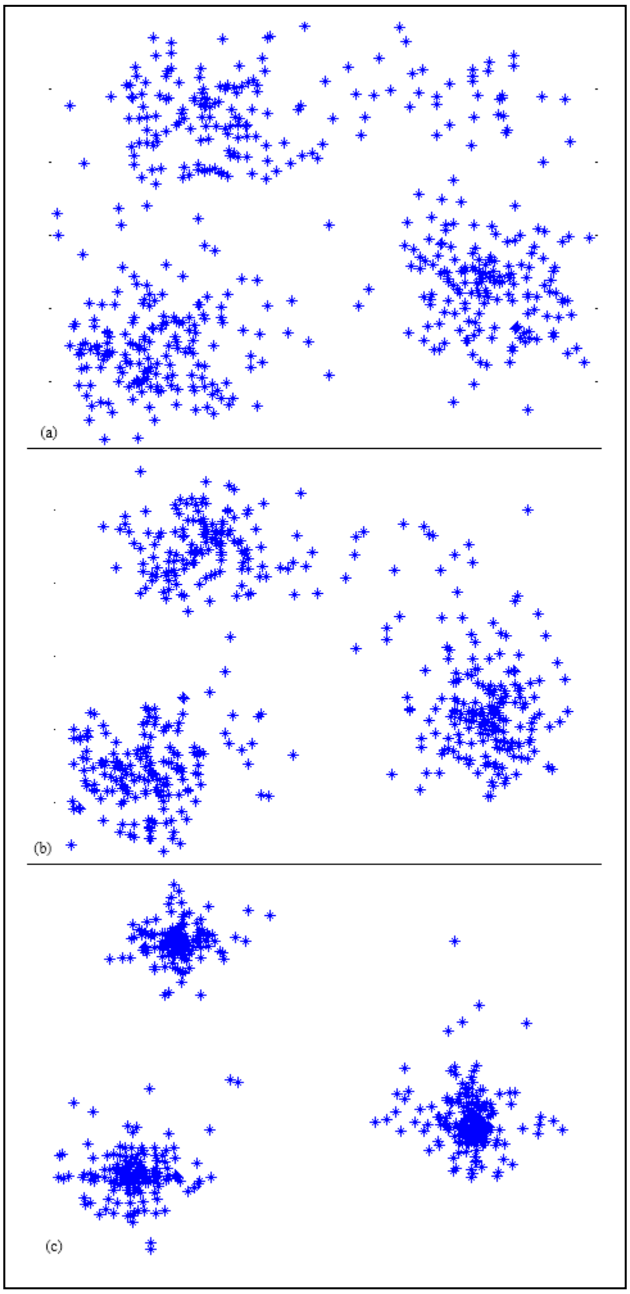

Fig. 3. Simulation of the participants' clustering process based on particle swarm theory

V. CONCLUSION

The dynamics of a cyber-movement is full of uncertainty, complexity as well as adaptability [13]. Therefore, it is sophisticated to exactly describe and predict the dynamics of a cyber-movement. In this paper, we pointed out that particle swarm theory can be used to model and simulate the dynamics of cyber-movement. The model based on particle swarm theory illustrates the clustering mechanism of participants and sheds

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