# Opinion Modeling Based on Meta-synthesis Approach

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**Abstract.** Harmonious opinion is indispensable to harmonious society. Opinion can be used as the benchmark or wind vane to judge social stability and harmony. Understanding and capturing the essential mechanism of opinion formation and diffusion will provide help for early forecasting and macro-regulation. Society is an open complex giant system (OCGS), in which controlling social opinion is a more complex system engineering project. This article firstly investigates various models for the dynamics of opinions from different perspectives. Next, combined concept modeling as a qualitative analysis method with multi-agent modeling as a quantitative simulation tool based on meta-synthesis approach is applied to the social opinion on exploring its essential mechanism. Finally, some concluding remarks and future works are given.

**Keywords:** opinion, open complex giant system (OCGS), meta-synthesis approach, multi-agent system.

## 1 Introduction

Harmonious opinion is indispensable to harmonious society. The degree of opinion harmony reflects and influences the degree of social harmony [1]. During the process of building a harmonious society, it is necessary to provide correct guidance of opinion infection for achieving the harmony of all types of development, construction strength, concept and relationship etc.

According to the various concepts of opinion, it can be defined as "the subjective reflects the public on certain social reality and phenomenon in a different historical stages, the integration of mass consciousness, ideas and emotion". This definition logistically covers the three main characteristics, namely subject, object and ontology, which are emphasized by the majority of domestic and foreign scholars in their definition of opinion. The subject of opinion is the general public, the object is a particular focus of the community, and the ontology is the tendentious comments or remarks of this focus [2].

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This paper, firstly, investigates various models for the dynamics of opinions from different perspectives, such as, mathematical opinion models, physical opinion models, etc. Next, combining concept modeling as a qualitative analysis method with multi-agent modeling as a quantitative simulation tool based on meta-synthesis approach is applied to the social opinion on exploring its essential mechanism. Finally, some concluding remarks and future works are given.

## 2 Research on Opinion Models under Different Perspectives

In China, research on social opinion from the view of sociology and the related disciplines didn't get enough attention until 1980s due to specialty of the conditions of the country and social psychology. Social opinion is a symbol of the progress of human civilization. Along with social opinion's infiltration into every walk of life, it becomes more and more complex, is involved into widespread research fields and gets more attention. To improve the qualitative description of social opinion for logicality, objectivity and repeatability, some natural scientists have applied themselves to research on social opinion. They usually didn't concentrate on concrete definition and concept, but provide fundamental proof for quantitative modeling on social opinion diffusion based on anatomy of opinion's essence and intension in the field of social science.

### 2.1 Mathematical Models for Opinion

Usually, researchers build some mathematical models and then try to describe, explain, forecast or find out some rules based on analysis of these models. An early formulation of such a mathematical model was given by J.R.P. French in 1956 in order to understand the complexity of group's activity [3]. In 1974, M.H.De Groot applied Delphi method to build consensus [4]. K. Lehrer & C.G. Wagner regarded rational theory as fundamental condition of modeling for social opinion from justice level to epistemology level in 1981 [5]. Especially, R.P. Abelson, N.E. Friedkin & E.C. Johnsen investigated how to achieve consensus or form social opinion from divergent thinking [6]. This solution can be described concretely as following.

Let n be the number of agents in the group under consideration. Each agent $i$ will not blindly accept or reject another opinion but consider other opinions totally and then form owned viewpoint. That is, opinion of each agent can be modeled by regarding other opinions with different weight value $w$.

French Model: with discrete conditions, weight value $w$ is constant.

Given the same hypothesis, opinion vector can be denoted with continues condition at time $t$ as

$$x(t) = (x_1(t), x_2(t), \cdots, x_n(t)) \tag{1}$$

Where, $x_i(t)$, opinion of agent $i$, is a real number. Let $w_{ij}$ be weight of effect on agent $i$ from agent $j$, then

$$x_i(t+1) = w_{i1}x_1(t) + w_{i2}x_2(t) + \cdots + w_{in}x_n(t) \tag{2}$$

$w_{ij}$ is a variable of time. It relates to $x(t)$ at $t$.

$$W(t, x(t)) = (w_{ij}(t, x(t))) \tag{3}$$

That is: $$x(t+1) = W(t, x(t))x(t) \tag{4}$$

This model can be simplified. Assume $W$ is a constant random matrix, then:

$$x(t+1) = Wx(t) \tag{5}$$

The above procedure is the kernel process of social opinion modeling by De Groot and Lehrer.

Based on the model by De Groot and Lehrer, Friedkin and Johnsen consider opinion of agent $i$ lies on two factors. The first one is insistence of owned opinion, described as $g_i$. The second one is effect from other opinions, described as $1 - g_i$. Formula (2) can be changed as

$$x_i(t+1) = g_i x_i(0) + (1-g_i)(w_{i1}x_1(t) + w_{i2}x_2(t) + \cdots + w_{in}x_n(t)) \tag{6}$$

With matrix mode, it can be expressed as,

$$x(t+1) = Gx(0) + (1-G)Wx(t) \tag{7}$$

This is Friedkin & Johnsen Model. The difference between this model and Abelson model is that differential equation instead of difference equation is involved in the latter on. These models often involve matrix theory, Markov chain and graph theory, etc.

### 2.2 Physical Models for Opinion

The Ising model has been well-known to be a simple model providing profound physical significances, which is helpful for discovering principles in our physical world [7]. It has been not only conceived as a description of magnetism in crystalline materials, but also applied to various phenomena as diverse as the order-disorder transformation in alloys, the transition of liquid helium to its suprafluid state, the freezing and evaporation of liquids, the behavior of glassy substances, and even the folding of protein molecules into their biologically active forms.

We consider an Ising spins chain ( $S_i$; $i = 1,2,3,\ldots N$ ) with the following dynamic rules:

if $S_i S_{i+1} = 1$, then $S_{i-1}$ and $S_{i+2}$ take the direction of the pair ( $i$, $i+1$ );

if $S_i S_{i+1} = -1$, then $S_{i-1}$ takes the direction of $S_{i+1}$, and $S_{i+2}$ takes the direction of $S_i$.

These rules describe the influence of a given pair on the decision of its nearest neighbors. When members of a pair have the same opinion, then their nearest neighbors agree with them. On the contrary, when members of a pair have different opinions, then the nearest neighbor of each member disagrees with him (her).

Deriving from the Ising model, Sznajd model [8, 9], Krause-Hegselmann model [10] and Deffuant model [10] have also been proposed for opinion dynamics.

### 2.3 Systemic Models for Opinion

Systems Science focuses on the structure, function (including evolution, coordination and control) and general rules. China's famous scientist Qian Xuesen gathers up and unifies achievements from the different disciplines with a systemic perspective, reveals the general rules and nature of system, and then builds the theoretical basis for systems science [11]. Objective of system science is various types of systems. According to amount of the elements and their different types, as well as degree of complexity of the relationships between different elements, systems are divided into simple system and complex system.

Some scientists have tried to study opinion from the perspective of systems science. For example, H. Haken, a famous physicist, proposed viewpoints as order parameter of opinion formation and considered that change in the number of viewpoints ($n_+$, $n_-$) is a cooperative effect. Also, he insists that the formation of viewpoint will be affected by the same or the opposite viewpoint [12]. Haken simply divides opinion into two contrary, positive and negative. That means, opinion is viewed as a simple system here.

## 3 Opinion Modeling Based on Meta-synthesis Approach

In fact, social opinion is formed after uninterrupted and complex interaction between individual utterances or attitudes and can be used as the barometer to judge social stability and harmony. So, it should be studied as a giant complex system. This paper intends to adopt Meta-Synthesis Approach (MSA) [13] as methodology guidance to research effectively on opinion formation and diffusion.

### 3.1 Meta-synthesis Approach

Meta-synthesis approach (MSA) is proposed to tackle with complex, open and giant systems by Qian, X.S. and his colleagues around the start of 1990s, which expects “to unite organically the expert group, data, all sorts of information, and the computer technology, and to unite scientific theory of various disciplines and human experience and knowledge” for proposing hypothesis and quantitative validating [13]. The essential idea of MSA can be simplified as “confident hypothesizing, rigorous validating”, i.e. quantitative knowledge arises from qualitative understanding, which

reflects the process of knowing and doing in epistemology. Later the concept of Hall of Workshop for Meta-Synthetic Engineering (HWMSE) is proposed as MSA practicing platform which is expected to utilize breaking advances in information technologies while the active roles of human beings are greatly emphasized during human-machine collaboration [14, 15]. There are three kinds of meta-synthesis, 1) qualitative meta-synthesis; 2) qualitative - quantitative meta-synthesis; 3) meta-synthesis from qualitative hypothesis to quantitative validation. Each kind of meta-synthesis can be supported by various tools or methods.

Society is an open complex giant system [16], in which controlling opinion diffusion based on the essential mechanism is a more complex system engineering project. This paper is combined concept modeling as the qualitative analysis method with multi-agent modeling as the quantitative simulation tool, and aims to explore some new perspectives, new methods and new ideas on opinion infection, and provides theoretical and methodological support for building harmonious opinion.

### 3.2 Concept Modeling for Qualitative Analysis

Qualitative meta-synthesis produces scenarios or hypotheses for the complex problems, i.e. to expose some qualitative relations or structures of the concerned problems. Opinion represents diffusion of the explicit awareness and presents ups and downs state. According to the different ability of people, there are different reactions. Wave ups and downs are exhibited because of the gap produced from different strength of diffusion. One conceptual model of opinion diffusion is proposed as below.

**Hypothesis:** There are $N$ opinion subjects, each of them owns viewpoint $o_i$, where $i = 1,2,\cdots N$.

**Definition 1:** The three basic elements of opinion infection involves { $\sigma$ : change of public behavior ; $E$ : environment of opinion infection; $t$ : time of opinion infection}, as following,

$$Y = F(\sigma, E; t) \tag{8}$$

where, $Y$ is speed of opinion infection on some social phenomenon or event.

Opinion diffusion is the process of choosing or being persuaded of each individual. Participants (or part of them) get agree on behavior finally. Therefore, the law of gravity can be referred to reflect change of individual behavior between moment $t$ and $t+1$ due to interaction. That can be expressed as,

$$\sigma_i = \sum_{j=1}^{N} k \frac{o_i \bullet o_j}{d_{ij}^{\alpha}} \tag{9}$$

Where, $k$ is the constant coefficient, $d_{ij}^{\alpha}$ represents the distance between the individual $i$ and individual $j$, $\alpha$ is the parameter of power, $o_i \bullet o_j$ describes the consistency between the individual $i$ and individual $j$.

If $o_i \bullet o_j > 0$, individual $i$ has the same viewpoint as individual $j$, then individual $i$ will hold the original viewpoint.

If $o_i \bullet o_j < 0$, individual $i$ has the opposite viewpoint to individual $j$, then, we can take following two conditions:

when $\sigma > 0$, individual $i$ will hold the original viewpoint.

when $\sigma < 0$, individual $i$ will change its proposition.

### 3.3 Multi-agent Modeling for Quantitative Simulation

Of course, having an explicit concept model with mathematical expression does not mean at all that one has explicit mathematical answers. With the development of complex adaptive systems theory, artificial life and distributed artificial intelligence technology, MAS (Multi Agent Systems) provides a good approach to address these issues. Agent (intelligent subject) is abstracted from the study of specific entities, which has their own initiative behavior, and is a "live" individual. Through establishing different decision-making rules for agents, a simulation model can be set up. In this paper, we use multi-based modeling to simulate the agents' behaviors with different interactive strategies to understand the dynamics of public opinion.

During opinion diffusion, the behaviors of the participants can be classified as "conformity", "power" and "egoism". In detail, "conformity" involves more psychological factors. Participants are fear of loneliness and obey to majority. "Power" mainly involves the moral values. Whether power or prestige is decisive factor, which is especially important in China. "Egoism" is driven by people's values. For some benefit, people may even change their words and deeds. Therefore, the "conformity", "power" and "egoism" are fundamental for the establishment of opinion infection simulation rules. Three transfer rules of opinion can be defined as following:

- The "conformity" rule: ask all their neighbors for their opinion, and then follow the arithmetic average of them.
- The "power" rule: convince all neighbors particularly if two neighboring agents have the same opinion.
- The "egoism" rule: each agent select one discussion partner at one time step. If their opinions differ by less than the confidence bound, their two opinions mutually get closer without necessarily agreeing completely.

***Simulation 1:*** Hypothesis, when $t$ =0, the number of opinion subject (agent) is $N = 10000$, there are $n = 5$ types of viewpoints, and the transfer probability is

$p_{O_{ij}} = p_{O_{ji}} = 0.1$, $a_{pi}$ is a random real number between 0 and 1. We require that only people with similar opinions talk to each other, namely, agents with viewpoint 1 can be talk with viewpoint 2, but can not be contact with viewpoint 3, 4, 5, if we defined the bounded is 1. The initial random spatial status can be described as figure 1.

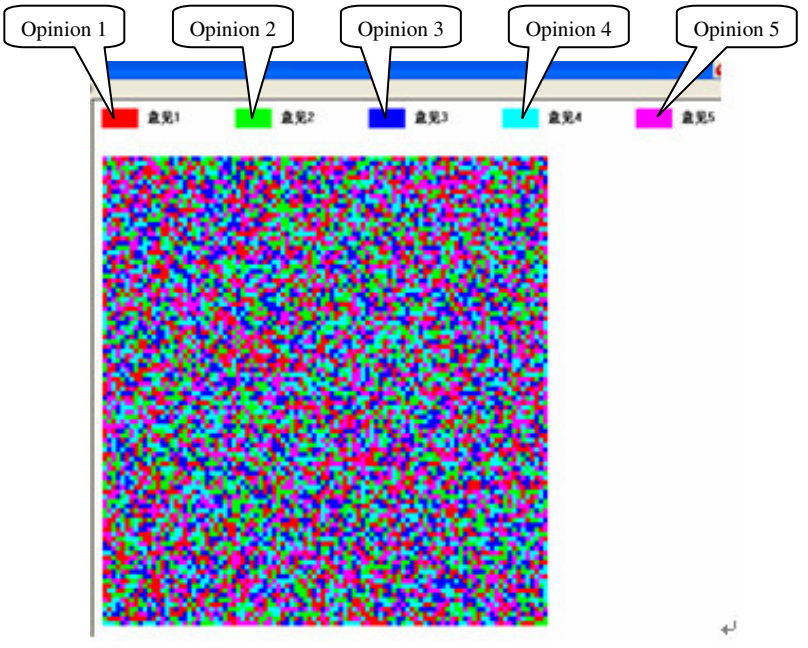


**Fig. 1.** Initial random spatial status of agents' distribution

According to the above conditions, with different rules of opinion transferring, respective results can be captured at $t$ =5 as shown in figure 2 (a), (b) and (c).

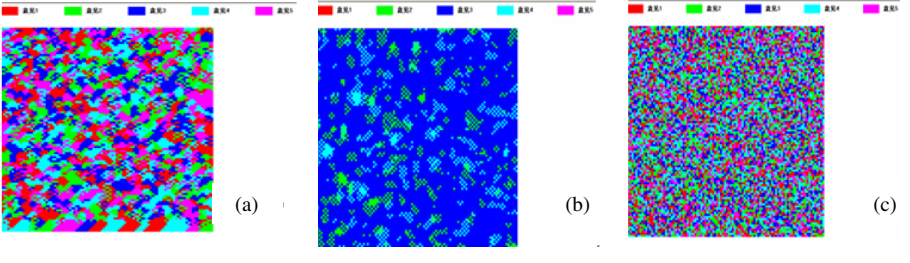


**Fig. 2.** When $t$ =5, (a) is the agents' distribution with "power" rule , (b) is with "conformity" rule and (c) is with "egoism" rule

When $t$=10, the corresponding status is described as figure 3 (a), (b) and (c).

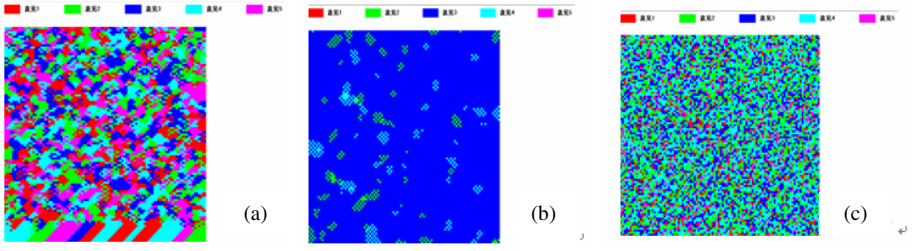


**Fig. 3.** When $t$=10, (a) is the agents' distribution with "power" rule , (b) is with "conformity" rule and (c) is with "egoism" rule

When $t$=20, the corresponding result is shown as figure 4 (a), (b) and (c).

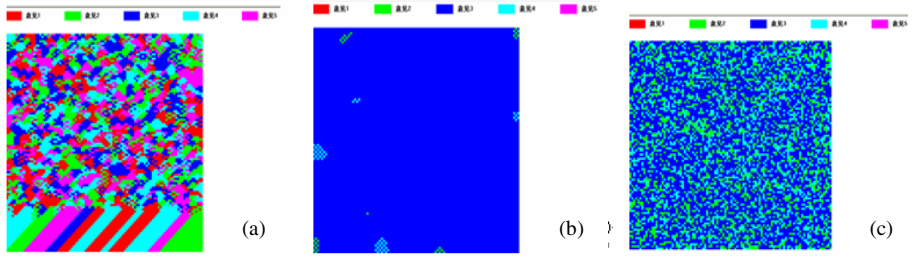


**Fig. 4.** When $t$=20, (a) is the agents' distribution with "power" rule , (b) is with "conformity" rule and (c) is with "egoism" rule

Above are the opinions' spatial scenarios, figure 5 (a), (b) and (c) can be found whose temporal evolution process.

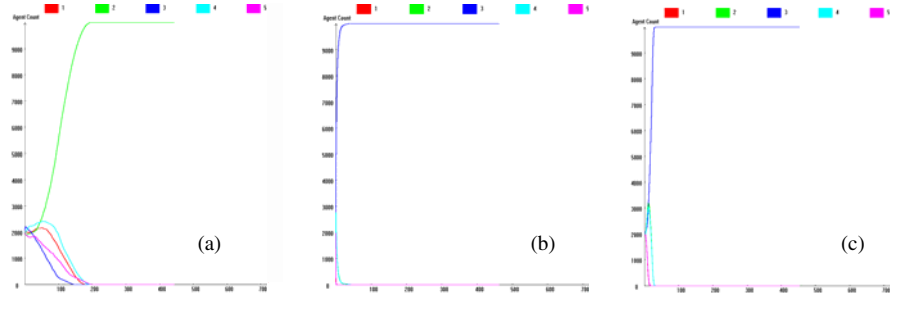


**Fig. 5.** From $t$=5 to $t$=20, five opinions temporal evolution process, (a) is the agents' distribution with "power" rule , (b) is with "conformity" rule and (c) is with "egoism" rule

***Simulation 2***: Hypothesis, most conditions are same with the simulation 1, only in $N = 10000$ agents, triplicate individuals, namely $N_1 = 3333$, are prefer to "power" rule, $N_2 = 3333$ stand to "conformity" rule, rest of the $N$ adhere to "egoism" rule. The initial random spatial status also be described as figure 1. Figure 6 (a) and (b) respectively show the spatial status when $t$=50 and $t$=100, consensus formation can be captured at $t$=500 as shown in figure 7. Temporal evolution process can be seen in figure 8.

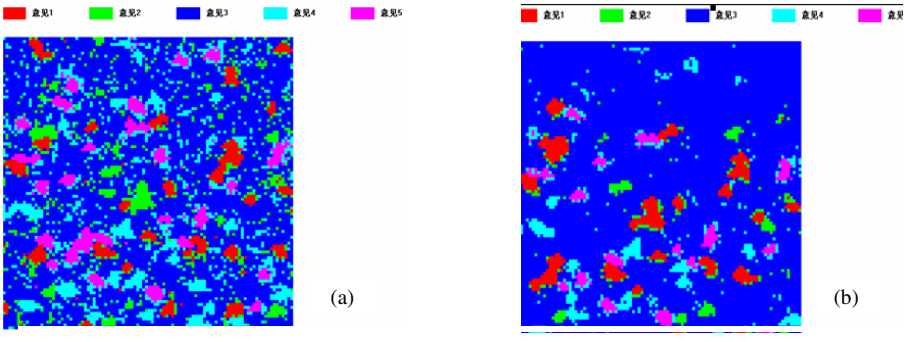


**Fig. 6.** (a) is the agents' distribution when $t$=50, (b) is the agents' distribution when $t$=100

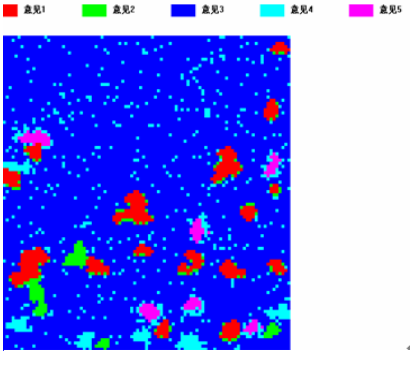


**Fig. 7.** Agents' distribution when $t$=500

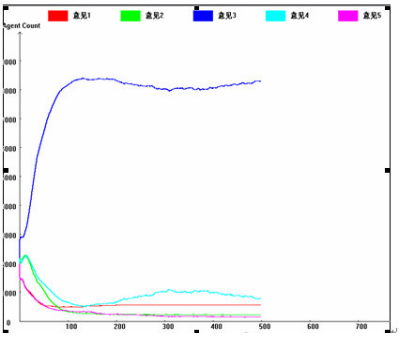


**Fig. 8.** From $t$=50 to $t$=500, five opinions temporal evolution process

Based on the above simulations and analysis, some conclusions can be drawn as following.

For the simulation 1:

- With the "power" rule, given opinion subjects (agents) holding five viewpoints, the viewpoint supported initially by more agents will get agree among more and more participants during opinion dynamics. In the scenarios of this paper, the viewpoint 2 with green color dominates the process of opinion diffusion.

- With the "conformity" rule, an opinion subject (agent) will continuously get average value between the five viewpoints. Trend of opinion diffusion is able to be determined by viewpoint 3.
- With the "egoism" rule, viewpoint of each agent will be transferred depending on corresponding probability when meeting agents with same or different viewpoint. The process of evolution is slower than "conformity" rule in the same simulation steps.

For the simulation 2:

- During the simulation steps, though viewpoint 3 is the consensus tendency in five viewpoints, but evolution speed is slowly than single preference by all the agents.

Till now, the practice of meta-synthesis approach to the concerned problems is addressed. Simulation 1 is the opinion dynamics under the single preference, and the other is multiple preferences. We wish the above analysis could propose an effective perspective and way for decision makers to aid them to make practical and feasible policies, such as suitable social opinion supervision and facilitation.

## 4 Concluding Remarks

In this paper, it is concerned to explore social opinion dynamics and produce one kind of concept and some demonstrations based on meta-synthesis approach. Such a kind of work aims to provide different perspectives for some systemic solutions instead of traditional ways toward social issues (topics about opinion). Forming of qualitative scenarios or hypotheses through concept modeling is the foundation for understanding the opinion's complex structure, simultaneously, multi-agent modeling as a core quantitative activity is also used to describe and analyze opinion's simulations based on assumptions.

Lots of further works are still under exploration, such as this paper only proposed two scenarios, more detailed simulation will be strengthened, three rules will be further explored in-depth, and the simulation platform for opinion diffusion will be gradually improved, etc. All which aim to explore more new perspectives, methods and ideas on opinion diffusion, and provide theoretical and methodological (MSA) support for building harmonious society.

## References

1. http://www.gov.cn
2. Liu, Y.J., Gu, J.F.: Systems Analysis and Modeling of Opinion Infection. In: Proceedings of IEEE SMC (2008)
3. French, R.P.: A formal theory of social power. Psychological Review 63, 181–194 (1956)
4. De Groot, M.H.: Reaching a consensus. Journal of American Statistics Association 69, 118–121 (1974)
5. Lehrer, K., Wagner, C.G.: Rational Consensus in Science and Society. D. Reidel Publication Company, Dordrecht (1981)

6. Friedkin, N.E., Johnsen, E.C.: Social influence networks and opinion change. Advances in Group Processes 16, 1–29 (1999)
7. Zhang, Z.D.: Conjectures on exact solution of three-dimensional (3D) simple orthorhombic Ising lattices (2007), http://arxiv.org/abs/0705.1045
8. Stauffer, D.: Sociophysics: the Sznajd model and its applications. Computer Physics Communications 146, 93–98 (2002)
9. Stauffer, D.: Sociophysics simulations, pp. 1–8 (2002), Arxiv, cond-mat.
10. Stauffer, D.: Sociophysics Simulations II: Opinion Dynamics, pp. 1–18 (2005), Arxiv. Physics
11. Xu, G.Z., Gu, J.F., Che, H.A.: Systems Science, Shanghai: Shanghai scientific and technological eduction publishing house (2000) (in Chinese)
12. Guo, Z.A.: Introduction to Synergetics. Sichuan renmin press, Chengdu (1988) (in Chinese)
13. Qian, X.S., Yu, J.Y., Dai, R.W.: A new Discipline of Science - the Study of Open Complex Giant Systems and its Methodology. Chinese Journal of Systems Engineering & Electronics 4(2), 2–12 (1993)
14. Gu, J.F., Tang, X.J.: Some Developments in the Studies of Meta-Synthesis System Approach. Journal of Systems Science and Systems Engineering 12(2), 171–189 (2003)
15. Gu, J.F., Tang, X.J.: Meta-synthesis approach to Complex System Modeling. European Journal of Operational Research 166(33), 597–614 (2005)
16. Qian, X.S.: Establishing Systematology. Shangxi Science and Technology Press, Taiyuan (2001) (in Chinese)