Knowledge Evolution of Complex Agent Networks

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Abstract. In order to study the interaction between structure change of social network and knowledge propagation, this paper proposes a complex agent network model to discover the inner rule and restraining factors of the knowledge diffusion in the network system. The agents take advantage of different social radius to form acquaintance networks based on the theory of social circles in the knowledge propagation network model, and the dynamic evolution process of knowledge network is realized according the defined rules of knowledge communication. Simulation results show that this model based on social circle theory can better realize the characteristics of the actual social network than the traditional network model established before, at the same time the social radius of knowledge agent for knowledge dissemination in knowledge network has the obvious effect. It can narrow the knowledge gap for the knowledge agents in social network and good social relation network can be developed.

1 Introduction

The study on the dynamic mechanism of knowledge communication based on complex networks has become the potential development direction of further research on knowledge dissemination. However, due to the complexity of knowledge dissemination in the social networks, the current research on knowledge communication is in a preliminary state, and the dynamics of knowledge networks system is just starting. In the real world, mutual influence exists between the dynamic interaction of knowledge dissemination and dynamic evolution of social networks structure, on the one hand, the social networks structure affects the performance and mode of knowledge dissemination, on the other hand, the social activities of knowledge propagation will in turn affect the dynamic characteristics of corresponding social networks. Cowan and Jonard[1]models knowledge diffusion as a barter process in which agents exchange different types of knowledge, and find that the performance of the system exhibits clear 'small world' properties, in that the steady-state level of average knowledge is maximal when the structure is a small world. On the basis of Cowan and Jonard models, Morone and Taylor[2] study the dynamics of knowledge propagation and the evolution of formation network in the process of interactive learning by considering the impact network structure on individual behavior. R Cowan, N Jonard, JB Zimmermann[3]model the formation of innovation networks as they emerge from bilateral decisions, they focus attention on the effects of the knowledge and information regime on network formation to study the co-evolution mechanism of knowledge communication in bilateral cooperation networks. Zhang Hao [4] studied the dissemination and diffusion of knowledge in universities by using the theory of small world network [5], and adjusted the relevant parameters to promote the virtuous circle of knowledge network by putting forward the concept of knowledge diffusion frequency and agglomeration degree of knowledge diffusion. The networks theory agent-based social circle [6] is used to construct the actual social networks model with a variety of statistical features of social networks. The social networks are generated through micro individual behaviors. The generation and evolution of the networks are managed by agents, and the evolution process of the networks is closer to the operation mechanism of the real society. So, the social circle networks model can flexibly describe the large-scale space-time coupling social networks.

2 Social circle network

For the sake of building social network model [7-9] with various statistical features of the social network, HAMILL L put forward the Agent-based social circles network theory. Firstly, each agent has different social communication radius and the space coordinates. Secondly, each agent generate the social networks with statistical properties of actual social network by their space position based on the social circles network theory, such as the differences in the radius of the individual networks lead to the differences in the network sizes, the network scale evolves over time, the network has a positive correlation, the evolution of the network can form a community structure ,the social networks have a relatively short average path, and the population density of the network community is low.

The social circles network model is based on the ideas of social space and distance, which abstracted as a

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larger social map to show the distribution and connection of the crowd in the society. The social circle of each individual represents the social scope of the individual, that is, the individual knows other individuals in his social circle, and the size of the social circle is described by the social radius. In the social circle network, the scale of the agent social networks varies with the size of the social radius, and the scale changes with time. At the same time, the social circle networks model has the characteristics of low population density, degree positive correlation, community structure with a short path and Poisson distribution with a fat tail. The micro knowledge communication network is a typical social network. The social circle network can reflect the characteristics of knowledge dissemination in the real society. So, the social circle network can be used to build the microscopic knowledge propagation network model.

3 Knowledge network models

Definition 1 Knowledge network model based on social circle is $SCs = (V(s), E(s), \varphi(s), R(s))$,where:

$V(s) = \{Agent_{ij} \mid i, j \in N^+\}$ is a non-empty finite set, which represents the type and the number of agent in the system.

$E(s) = \{e_k \mid k \in N\}$ is a finite set that doesn't intersect with a $V(s)$,which represents the number of edges associated with agent in the system.

$\psi_s = \{r_{xy}, x, y \in V(s); x \neq y\}$ is the mapping function of the correlation relation between different agents in the system. $r_{xy} = 1$, it means that there is a direct connection between x and y , $r_{xy} = 0$, it indicates that there is no edge between x and y .

$R(s)=\{rule_i | i \in N\}$ is the rules set in the system.

Definition 2 Agent is a 4-tuple $Ag = (m, v, k, a)$,where:

m is the identity of agent, which is unique and consists of digital strings.

v is the category of agent, which is used to distinguish types of agents in the system.

k is the local knowledge library of agent, which represents the basic cognitive level of each agent .

a is the personality of agent, which represents the individual performance of the agent in the process of knowledge dissemination, it is defined as follows:

$a = (p, sr, r, lk)$, where:

p represents the location in the two-dimensional space where agent is located.

sr represents the size of social radius for agent.

r is the strength of the relationship, which is a measure of the degree of relationships between the agent and the neighboring agents.

lk is the knowledge level, which means that the amount of agent knowledge.

4 Simulation and results

To achieve the simulation of the model, the simulation platform adopted in this paper is an agent-based development tool, Net- logo 5.1, which is especially suitable for modeling complex systems with time series. The user can establish the interaction of macro models and micro-behavior, and the dynamic knowledge network system can emerge by the interaction between independent agents. Netlogo uses a simple logo language structure, which inherits the related concepts of the logo language. The main body is represented by turtles, while the environment of turtles is represented by patches and the system network was built by the linking (directed edge and undirected edge).

4.1 Social network evolution

The self-centered social networks (personal network) show the relationship between individuals and others. The social network is the aggregation of the individual networks, and the size of the individual network depends on the type of relationship in the network. Based on relationship strength, Boissevain[10]divided the relationship into strongest relation (the closest person or friends, closest to the strongest connection total is about 5), strong relation (often contact person or good friends, the number of 5 to 10), medium relation(contact friends or not often contact friends, the number of 20 to 30), weak relation (the daily economic activities related to the people, about 100 to 500), the weakest link (that may know, the number can be more than 500). At the same time, Boissevain believes that a few individuals have a large number of connections, while most individuals have fewer connections. Gilbert [11] research shows that the maintenance of social networks requires cost, so the size of a personal network is limited. The social relations network model shown in Figure 1 is generated by randomly distributing 1000 agent in 100000 unit area in two-dimensional space, where (a)(Sr=15) and (b)(Sr=45) denote the initial social relationship network generated by the social radius (SR) of 15 and 45, respectively. Besides,(c)(Sr1=15,Sr2=30) and (d)(Sr1=25,Sr2=45) means that the social radius(Sr1) of 80%agents is set to 15 (or 25) (the most agents in a social network have less knowledge, because their vision range is small, and only a small range of other agents are connected to form a small circle), and the social radius (Sr2) of 20% agents is set to 35 (or 45) (such as the key figures, who act as knowledge disseminator in the knowledge network, whose social circles should be large, and also plays the role of connecting the different small circle). Figures 2, 3 show the network degree distribution and cluster coefficient distribution of the initial social relations network shown by Figure 1 (d).

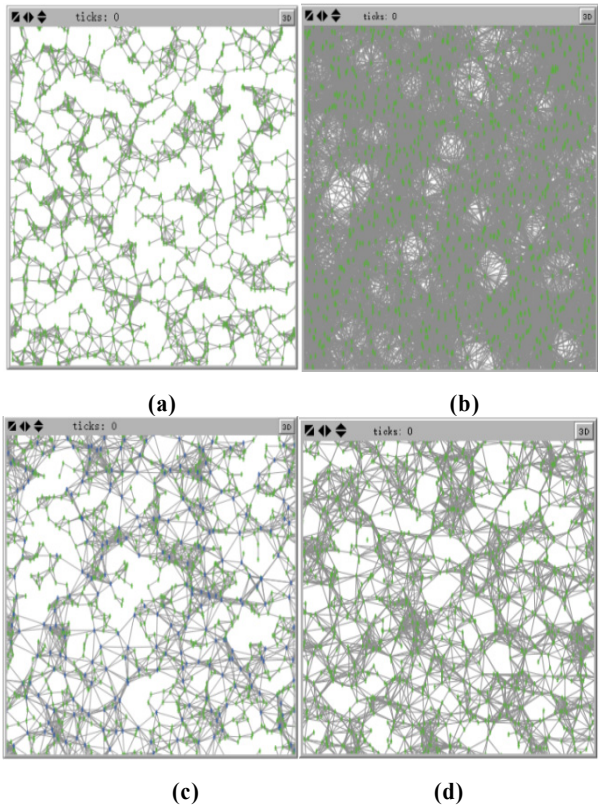

Fig. 1. Social network of different radius

The social network model constructed by the social circle theory can realize most of the characteristics of the social network. In terms of individual networks, firstly, to limit the network scale and match the generated network with the actual social network through the social circle. Secondly, the size of the social circle can be adjusted by the social radius to find the parameter values of two suitable social circle sizes that form a continuous long tail distribution. Thirdly, there is a higher clustering coefficient in the social network. Fourthly, the individual network can move with time. For the whole network, social network has low density, exists significant positive correlation between degree and degree, and community structure and short path length. So, it can be seen that the social network model embodies the social network structure characteristics of the knowledge communication network.

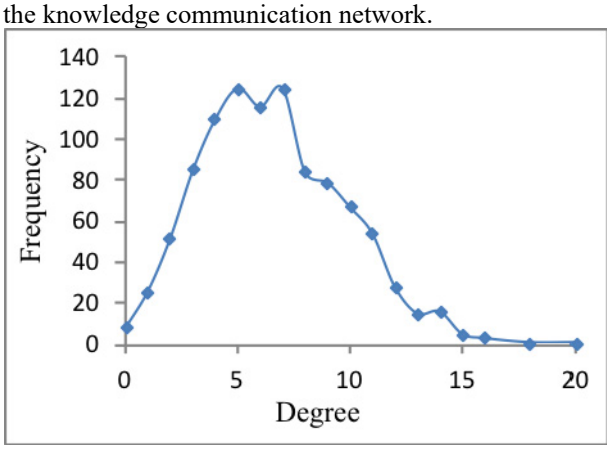

Fig. 2. Degree distribution

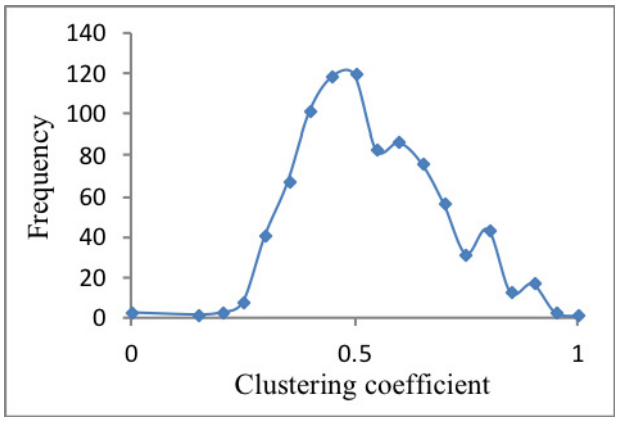

Fig. 3. Clustering coefficient

4.2 Knowledge network evolution

In the actual complex relationships of social network, due to the heterogeneity of knowledge agents, the social radius of each knowledge agent in the society is different based on the influence of many factors such as social status and social environment. For simplicity, we assume that the social radius of knowledge agent in the knowledge network is divided into two categories: Sr1 and Sr2 (Sr1 stands for smaller social radius, and Sr2 represents the larger social radius), p is the ratio of the number of knowledge disseminators to the total number of people.

In order to study the influence of the social radius of knowledge disseminators and the ratio of the people on knowledge dissemination in actual knowledge network, as shown in Figure 4, we simulate the different social radius Sr1 and Sr2 and the ratio of knowledge propagator P. The simulation results shown in Figure 4 show that when determining the value of Sr1 and Sr2 in knowledge network, we can change the efficiency of knowledge dissemination in knowledge network by changing the ratio of the total number of knowledge agents in the knowledge network system (the mean radius of the social network is 40). When the P value is large, the mean of knowledge increases in the knowledge network system, due to its larger social radius, faster speed for the dissemination of knowledge in the knowledge network, so the whole knowledge network system can reach a higher knowledge level in a relatively short period of time. When the number of knowledge disseminators reaches a certain proportion in the network, as shown in Figure 5, such as the value of Sr1 is 10, the value of P is 30%, it is the knowledge propagation process under different social network structure (Sr2 different values). From Figure 5, it can be found that when the radius of knowledge network becomes larger and larger, that is to say, the circle of acquaintances become larger. At the same time, with the increase of knowledge receivers, the knowledge transmission efficiency of the knowledge network system is higher; the time will be significantly shorter for knowledge network system achieving a higher level of knowledge.

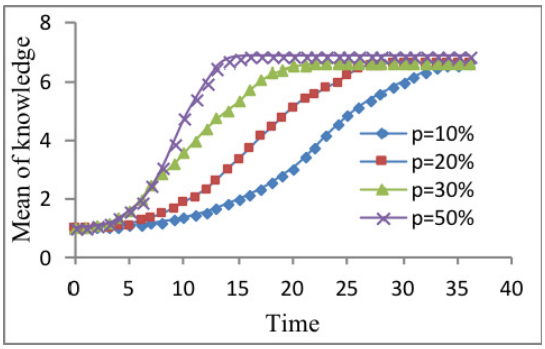

Fig. 4. when Sr_1=20 and Sr_2=40, knowledge network evolution graph for different p value

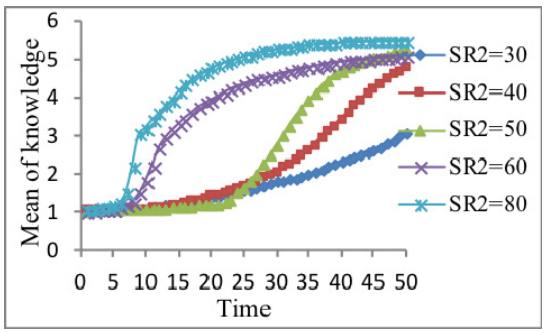

Fig. 5. when P=30%, knowledge network evolution graph for different social radius

5 Conclusion

A complex agent dynamic network model is proposed in this paper. Based on the theory of social circle network, the relationship between the network structure and the knowledge transmission of knowledge network system is simulated. In this model, knowledge agent generates social network of acquaintances through social radius and realizes the dynamic propagation process of knowledge network under the constraint of the rule of knowledge propagation and rule of knowledge evolution. The simulation results show that the social radius of knowledge disseminator and their proportion in the whole knowledge network all play a positive role for optimizing the network system structure and knowledge evolution efficiency.

Acknowledgements

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