PSOを用いた集合知のモデル
Collective Intelligence Model through PSO

高橋徹[*1] 山田隆志[*1] 寺野隆雄[*1]
Toru TAKAHASHI Takashi YAMADA Takao TERANO

[*1] 東京工業大学大学院知能システム科学専攻
Computational Intelligence and Systems Science, Tokyo Institute of Technology

This paper proposes an information transmission model through Particle Swarm Optimization (PSO). This model enables us to manage the complexity of information topic. We consider the factors of PSO as the three aspects of the information transmission: 1) the structure of network, 2) the value of information, and 3) the character of agents. Our main findings are 1) the relation between topics and the information network, 2) how the character of agent affects, and 3) the characters of agents based on his degree.

1. Backgound

In recent years, agent-based simulation (ABS) has been used for analyzing a transfer of information. By this approach, the processes of cultural trend or diffusion for marketing are clarified. Especially, ABS as a bottom-up approach seems helpful when modelers take into account interactions between individuals affecting the transfer of information.

There are several researches to analyze the information transmissions [Kunigami 07, Toriyama 08]. As a matter of fact, those earlier studies have dealt with culture and knowledge, but in our view they are substantially same as the transfers of information. In this paper, we define category, such as cultures and knowledge, as ‘topic’, and actual culture as ‘information’.

Those previous studies have assumed that the values of information are equivalent to each other. However, in some topics, the values are obviously diffrent. On the contrary, the value of information is not easily judged from the perspectives of similarities of information. In other words, the best information is not always similar to a piece of good information (e.g. development of products). Threfore, the landscape of such a topic has a complex architecture.

2. Proposal

We build an information transmission model using Particle Swarm Optimization (PSO). Which means, we address complex qualities of topics extending KISS principle[Axelrod 97]. However, topics mean categories, and information is a piece of topics. The hypotheses of this model are as follows: 1) Information in a topic has a value. 2) An agent can accurately see it, and he/she search information as good as possible. 3) The landscape of topic is static, in other words, the value of information is not valuable according to time.

In constructing our simulation model, we incorporate 1) the structure of information network, 2) the value of information, and 3) the character of agents into it to examine the relationships between information networks and landscape of topics. Then, each of them corresponds to the factors of PSO: 1) the network consists of links between particles, 2) the value of the function, and 3) the update formula.

連絡先：高橋徹，知能システム科学専攻，神奈川県緑区長津田 4259J2-1705，045-924-5215，toru@trn.dis.titech.ac.jp

3. III. INFORMATION TRANSMISSION MODEL

3.1 A. Particle Swarm Optimization (PSO)

PSO proposed by Kennedy [Kennedy 95] is one of the optimization methods and has been applied to many cases. PSO consists of particles, each of which moves in a problem space. A particle determines the point to move based on information of others.

Each particle has a velocity vector v and a position one x. They calculate v and x by formulas (1) and (2) respectively:

$$v_{k+1}=w \cdot v_k + C_1 \cdot rand_1 \cdot (pbest_k - x_k) + C_2 \cdot rand_2 \cdot (gbest_k - x_k) \quad (1)$$

$$x_{k+1}= x_k + v_{k+1} \quad (2)$$

Where the variables “k”, “rand” mean update times and uniform random numbers between 0 and 1 respectively. The variables “w”, “C1”, and “C2” are some constants. The first term of equation (1) means inertia from before time. The “pbest” in the second term, called self-recognition, is the current best position vector for an individual particle. The “gbest” in the third term, called social recognition, is the current best position vector for all the particles. Thus each value of “w”, “C1”, and “C2” is considered as strength of each factor.

Another model introduces a network to PSO. modified formula (1) as follows:

$$v_{k+1}=w \cdot v_k + C_1 \cdot rand_1 \cdot (pbest_k - x_k) + C_2 \cdot rand_2 \cdot (lbest_k - x_k) \quad (3)$$

It defined link between particles. And particle gets information from others have link to him. So, “lbest” is the best position vector, a particle get through links.

3.2 Overview of the Model

There are three aspects in the proposed model, namely 1) the structure of information network, 2) the value of information, and 3) the character of agents. In this part of the section, we explain these analogies in PSO.

First, in expressing the structure of information, we employ PSO with network structure. In this setup, we define a particle as an agent, and links between particles as information network.

Second, we assume that the value of information is an optimzation function in PSO. For example, if one selects Rastrigin function as the optimization function, the landscape of the topic is multimodal.

Third, we express the characters of agents as the fixed numbers in the update formula (1). Which means, the variable C1 is how much an agent has confident with her own information, and the variable C2 is how much her possessing information is influenced by that of others.

3.3 Agent

The parameters for the agents are as follows (Table 1): “Searching position” represents the information which the agent evaluates, whereas “searching direction”. “The best information” is the information which the agent has ever found. The agents acquire other information through “information network”. “Preference of information the agent find by himself” and “effect from information other agents have” mean the agent emphasize his information and other’s information respectively.

Figure 1 is the flow in one step.

4. Experiment

4.1 Experiment Settings

In this experiment, there are 200 agents in this model. There are two kinds of topics and six kinds of information network structures.

The types of topic involve monomodal type, multimodal type. They correspond to Sphere function, Rastrigin function.

The types of information network structures involve six types: the complete graph, the star graph, the regular network, the random network, BA model [Barabási 99], and WS model [Watts 98].

The parameters for the agents are different in each experiment except w in equation (3). namely we fixed w as 0.60.

At first, we investigate the relations between topics and the information network. Therefore, the two parameters C1 and C2 were fixed as 1.0 and 2.0 respectively.

4.2 Experiment Results

Figures 2, 3 show the information processing capability with various structures of networks on each topic. Each graph shows the average of 1000 simulations, which computes the average result of the value of all agents’ best information. Its y axis is logarithm-scale and the upper is lower value.

In the case of BA model, hub agents have high effects. Thus, It finished fast, however, not searched well. WS model and the regular network do not have hub agents. Then, it took a longer time for them to converge than others. On the other hand, they searched information particularly and obtained good information.

In the case of the multimodal topic, the complete graph is as bad as the star graph, the contrary to the monomodal topic. Because, agents were deceived with the information which was apparently good.

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Select one agent randomly.
Update agent's searching direction by formula (3).
Update agent's searching position by formula (2).
if the value of the best information < the value of searching position
    agent's the best information = searching position
end if
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Figure 1. The flow of one step

Table 1. Correspondence relation between information transmission model and PSO

Information Transmission Model	PSO
Topic	Function $f(x)$
Information	x
Agent	Particle
Searching direction	Velocity vector
Searching position	Position vector
The best information	*pbest*
Information network	Links between particles
Preference of information the agent find by himself	C_1
Effect from information other agents have	C_2

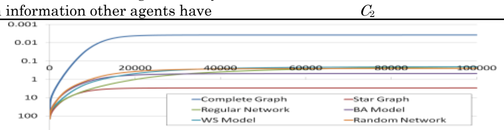

Figure 2. The result of the monomodal topic

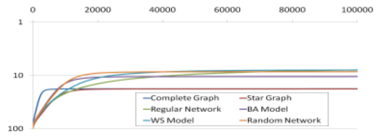

Figure 3. The result of the multimodal topic

5. Conclusion Remarks

This paper proposed the information transmission model could address a complexity of a topic. We revealed some knowledge from it.

There is a trade-off between the speed of transfer and the efficiency of the search for good solutions.

In the case of monomodal topic, the complete graph obtains good information. On the other hand, in the case of multimodal, it is deceived with the information which is apparently good.

This paper only proposes the model can address a complex topic. In future works, we append various factors to represent a certain information transmission.

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