ANALYSIS FOR FASHION EMERGENCE BY AGENT-BASED SIMULATION

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1. INTRODUCTION

We are often said to be so weak to pressure from a group that we tend to conform to a majority in a group (Asch S., 1951). Nevertheless, the real society is not uniform. Latané shows diversity in a system in Dynamic Social Impact Theory (DSIT) as follows: though a majority increases in number as time, a minority never disappears in spite of decreasing in number because it survives by clustering locally (Latané B., 1997). Therefore diversity is kept in a system.

Ishiguro et al. introduce global information (Ishiguro I. et al., 2000). In their model, global information behaves as a generalized other. This fifth agent brings two paradoxical changes to DSIT results. One is that it prompts the consolidation by increasing a majority. Another is, meanwhile, it may keep a system from uniforming. When the size of minority is comparatively larger, the number of clusters increases though the average size becomes small.

However, if a majority always increased in number, any changes wouldn’t happen in our society. It has developed through accepting something new. Social diffusion, such as fashion or innovation has a reverse process that a minority increases in number as times. Fashion emerges as follows: at first, a few people adopt a new style. Someone evaluates and may mimic them. When this interaction increases adopters to majority, the new style becomes fashion. It can be said that fashion is a process of social diffusion by which a new style is adopted by some group(s) of consumers interacting with each other (Solomon M R., 1996, Kawamoto M., 1981). Fashion is not only peculiar to clothes. It includes a prevailing or preferred manner of dress, adornment, behavior, word, thought or way of life at a given time (Solomon M R., 1996). Here we define the word “fashion” as a kind of social diffusion with prevailing processes of minority. All of these have a mechanism that a small fluctuation spreads over the whole system in common. Our goal is to determine how it occurs and what brings it.

2. AGENT-BASED MODEL

We construct a virtual society consists of agents. Our basic concept lies on the complex system: the activities in micro levels build a macro one, and also the upper level determines the behaviors in the lower ones. Here, agent is micro level; it receives information as inputs and decides its
attitude as output. The set of outputs each agent has done determines the state of a macro level. Fashion is a phenomenon observed in a society of a macro level by the result of the agents’ behaviors. Therefore, this model is built taking notice of agents’ behaviors that bring a phenomenon and interaction between two levels, then determined how fashion emerges through observing the macro level. Our way integrates two levels that have been studied separately. This paper doesn’t deal with its end, since we focuses on the emergence of social diffusion.

Our model is regarded as a development of Cellular Automata (CA). The feature of CA is as following:

- Discrete Space: It consists of not continuous but discrete cells.
- Discrete time: the value of each cell is updated at some discrete interval.
- Discrete state: Each cell has one of the finite values.
- Uniformity: Each cell is homogenous, and is put in order regularly.
- Simultaneous updating: All cells are updated simultaneously.
- Spatial local rule: Only nearby cells influence the cell updating.
- Temporal local rule: Only the last few steps (usually the exactly previous step) influence the cell updating.
- Universal function: Each cell applies the common value and the function as the updating rule.

One cell stands for one agent, which has properties for each: tendency, attitude and threshold. Each cell behaves according to its own internal rule. The system consists of all cells represents “society”. We simulate under various conditions changing agents’ properties, and then analyze what results in a society by observing cells.

3. LOCAL INTERACTION MODEL

Agents get information from neighbors. They become adopter when influence exceeds their thresholds. Here, influence comes from neighbors. The number of adopters around an agent is defined as local information, which works as local influence to the agent. Agents’ tendencies are based on thresholds i.e. pioneer and follower (Simmel G., 1971). Pioneers are agents who are so sensitive to influence that they tend to become adopters rather than followers. In short, pioneers have lower thresholds than followers.

The simulation is experimented as the following: 100 agents are distributed on the 10 by 10 lattice without overlapping at random. Any movements of agents are not considered. This paper applies Neumann neighborhood, which means that each agent checks four directions neighbors (up, down, left, and right) with the exception that marginal agents do two or three. The important thing is that even if adopters are majority in the system, they are minority for an agent when the agent has only an adopter in its neighbors, and vice versa. This is local interaction model agents interact with neighbors only because of their finite sight range.

An adopter has one influence on its neighbors. When the accumulated local influence \((LI)\) exceeds the threshold, the agent changes its attitude. The adopting rule is:
pioneer:

\[ a_{t+1}^{(i,j)} = \begin{cases} 
1, & \text{if } LI_i^{(i,j)} = 1 \\
0, & \text{if } LI_i^{(i,j)} = 0 \| LI_i^{(i,j)} > 2 
\end{cases} \]  \[1\]

follower:

\[ a_{t+1}^{(i,j)} = \begin{cases} 
1, & \text{if } LI_i^{(i,j)} < 2 \\
0, & \text{if } LI_i^{(i,j)} > 2 
\end{cases} \]  \[2\]

\(a_t\) : attitude at the step \(t\),

\(i, j\) : position, \(0\) : reject, \(I\) : adopt

LI: the number of adopters around the agent

If \(LI_i^{(i,j)} = 2\), then \(a_{t+1}^{(i,j)}\) will not change in the both tendencies. Giving to the number of initial adopters and pioneers, agents begin interactions one another. They decide their attitudes, adopting or not, once in a step. One round consists of 30 steps. The average number of last five steps provides the number of final adopters in the round. Since agents are distributed at random, each round has the different results under the same condition, which has the same number of initial adopters, pioneers. 1000 rounds simulating gives the maximum, minimum and average number of adopters under the same condition. The average number of final adopters is used for analysis.

The simulation results point out two cases that initial adopters expand. One is the case with the small number of followers and initial adopters. Another case is that there are many followers and initial adopters.

Graph 1: Change of the Number of Final Adopters

Graph 1 illustrates the average number of final adopters increasing initial adopters 0 to 100 when the number of pioneers is 0, 13, 29 and 100. If the number of pioneers is between 13 and 29, final adopters always decrease in number. When there are less than 12 pioneers, initial adopters can expand as long as they are majority. Contrary to this, when there are 30 pioneers or more, initial adopters can expand when they are a minority. Seen from another viewpoint, the majority is those
who are not adopters and they increase in the former case. Therefore a minority is expanded in a system with many pioneers, and reduced in a system with few pioneers. The latter case seems to explain DSIT.

Table 1: Distribution of Final Adopters (%)

<table>
<thead>
<tr>
<th>pioneer</th>
<th>0</th>
<th>10</th>
<th>20</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>average</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>20</td>
<td>34.7</td>
<td>66.3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.9</td>
</tr>
<tr>
<td>40</td>
<td>3.4</td>
<td>26.2</td>
<td>11.7</td>
<td>0.8</td>
<td>0</td>
<td>0</td>
<td>6.4</td>
</tr>
<tr>
<td>60</td>
<td>0.1</td>
<td>9.4</td>
<td>16.4</td>
<td>15.1</td>
<td>40.3</td>
<td>18.6</td>
<td>0.1</td>
</tr>
<tr>
<td>80</td>
<td>0</td>
<td>0</td>
<td>6.2</td>
<td>0.1</td>
<td>0.1</td>
<td>28.9</td>
<td>64.6</td>
</tr>
<tr>
<td>100</td>
<td>0.2</td>
<td>0.1</td>
<td>5.6</td>
<td>0.1</td>
<td>0.1</td>
<td>4.3</td>
<td>89.6</td>
</tr>
</tbody>
</table>

(Initial adopters = 3, \( \kappa = 0 \))

Table 1 shows the distribution of final adopters beginning at 3 initial adopters. As pioneers increase in number, the average becomes larger. For instance, 3 initial adopters averagely expand to 20.7 concentrating in the column “~40” when there are 60 pioneers. However provided 20 pioneers, they are reduced to 0.9 at last.

As for the maximum number of final adopters, it seldom changes after a certain number of initial adopters. For example, the maximum number of final adopters with 10 pioneers keeps 90 in over 73 initial adopters. Also the one with 100 pioneers converges to about 60 at 2 initial adopters and seldom change any more after then. This implies the number of pioneers determines the maximum capacity of system.

4. INTEGRATED MODEL

Here, global information is added to the previous model. Agents behave based on two kinds of influence: global and local influence. Akuto insists people recognize something by impersonal information and evaluate it by personal information (Akuto, H. 1992). Applying his model, agents make decision based on local information same as the local interaction model, and we add global information there as what changes their adopting rule. Global influence \( GI \) is denoted by the below formula:

\[
GI = kN^i
\]

\( (k, i \) is constant, \( i < 1 \), \( N \) is the number of adopters) \]

Global influence is updated for every step. \( GI \) becomes larger with adopters increasing in number, but the increasing rate per adopter becomes smaller. Agents have two thresholds to each influence. The distribution of thresholds to global influence follows the normal distribution; the number of agents with the lower or higher threshold becomes smaller (Rogers E M., 1962). In this model, pioneers are the agents with the lower threshold to global influence. For instance, when there are 30 pioneers, they are the agents to 30th with lower thresholds. When \( GI \) exceeds
the thresholds, the agents are influenced and recognize. The influenced agents can adopt at lower local influence so that their adopting rules agents are:

pioneer:

\[ a^{(i,j)}_{t+1} = \begin{cases} 1, & \text{if } LI^{(i,j)}_t < 2 \\ 0, & \text{if } LI^{(i,j)}_t > 2 \end{cases} \]  

If \( LI = 2 \), then pioneers keep current attitude

follower:

\[ a^{(i,j)}_{t+1} = \begin{cases} 1, & \text{if } LI^{(i,j)}_t \geq 2 \\ 0, & \text{if } LI^{(i,j)}_t < 2 \end{cases} \]  

**Graph 2: Change of the Number of Final Adopters \((k=10)\)**

Global influence is added to the previous model in Graph 2 (mass effect \( k=2 \)). It is same that a majority expands when there are many followers and a minority does when many pioneers, but comparing to Graph 1, initial adopters expand much easily and larger. For instance, with global information at least 43 initial adopters are needed to increase without pioneers. If no global information, more than 60 initial adopters are needed. And besides them, there is another range to expand where initial adopters increases in number. In the middle number of initial adopters, around 50, it always increases. There are no pioneer ranges to always decrease such as Graph 1.

In Graph 3, comparing the case with global influence (A) and without it (B). A is 35 pioneers and global influence \((k=10)\). B is the case with 70 pioneers and no global influence. 3 initial adopters averagely expand to about 30 in the both cases. The average followers’ rate of adopters at the step 30 is 44.5 for A and 5% for B. The maximum number of adopters in the case A is 72, which consist of 83.3% followers. In the case B, it is 57, which consist of 24.5% followers. Global influence makes the maximum number and followers’ rate large. In the case A, though the number of pioneers at the step 8 is 29, it is reduced to 13 at the step 30. Global influence promotes to spread fashion by making pioneers convey it to followers, however, which causes pioneers to stop adopting because of too many adopters around them. Therefore the number of adopters of pioneers decreases as total adopters increases in number.
5. CRITICAL MASS

Graph 4 shows the results of 1000 rounds in ascending order with global influence changed. As global influence becomes stronger, the number of maximum adopters becomes larger. The number of maximum adopters is the capacity of system, so that global influence works to enlarge the capacity.

Considering a state of final adopters as an equilibrium state, the system with more pioneers has much more equilibriums. As shown Table 1, equilibriums are distributed more widely with the number of pioneers increased. The more pioneers are, the wider the distribution is. For example, final adopters are distributed between 0 and 11.0(51.0), 65(40.3)% in the case of 20(60) pioneers. Graph 4 shows that global influence also enlarges the distribution range as it becomes stronger. When there are 20 pioneers, the results are distributed between 0 and 20. On the other hand, they are between 0 and 60 when 60 pioneers.

The behavior of agents brings about an unexpected order spontaneously. When there are enough
pioneers, a critical mass is found. A critical mass is that once prevailing rate exceeds the point, it expands explosively. At the above Table 1, the number of final adopters flies to 37.8 from 20.2 when there are 80 pioneers. The case with 40 pioneers doesn’t have such point when there is no global influence $k=0$, but it creates the critical mass by increasing global influence (Graph 4). Unless there are no pioneers, however strong global influence is, it doesn’t appear. Therefore pioneers form a critical mass and global influence promotes them to create it.

6. ANALYSES AND DISCUSSION

Fashion appears in a society with many pioneers. Akuto points out that fashion would occur when the society is not stable. A stable society means a robust system that has such a strong pressure to remove a small fluctuation that a minority decreases in number as shown in DSIT. On the other hand, an unstable society is so fragile to a small fluctuation that it cannot keep the homogeneity. The initial state of society changes easily to another state. Because pioneers are not content to belong to a majority, they make society unstable and bring about fashion. Ikeuchi classifies social states into “dynamic” and “static” (Ikeuchi, H. 1968). The dynamic society prompts to prevail meanwhile the other inhibits fashion. A dynamic society is characterized by increase of the speed, range and frequency of communication and transport, fluidity of power constructers and so on. Global influence represents it in our simulation. As global influence is larger, the frequency of fashion emergence is increased and the scale becomes bigger. Intuitively, the dynamic society seems to include many pioneers. On the other hand, the static state like a conservative society consists of many followers. He continues, “A dynamic society is an opened one idealized by change, progress, development and expansion comparing that static society idealized the status quo”. Dynamic society is sensitive for change and “unstable” in that it doesn’t orient with the status quo.

The state of final adopters represents the equilibriums of system. Fashion is considered as one of the results among possible equilibriums. Pioneers and global influence enlarge the distribution range of equilibriums. This also proves the instability of system because small initial differences may bring out quite different results in the system with lots of equilibriums. Brian Arthur states competitions between technologies may have multiple potential outcomes. It may happen that a technology that by chance gains as early lead in adoption may eventually dominate potential adopters (Arthur W B., 1986). Fashion is common to his theory.

Global information forms fashion with many followers, meanwhile the system without it emerges fashion consists of many pioneers. The former state is considered more robust than the latter. Adding a new fluctuation, a state supported by many pioneers would easily change to another state but fashion consists of many followers may keep the existing state. If categorizing fashion by the robustness (or holding period), the former case is fad called “collective fool” because it expands and disappears relatively quickly.

7. CONCLUSION
The results reveal the condition that fashion emerges. A small fluctuation can spread over in the system with many pioneers and global information. Pioneers are so sensitive to influence that they become adopter at the earlier step and increase adopters through influencing others. They create a critical mass, which is characteristic of fashion emergence. Once the number of adopters exceeds the point, the positive feedback works strongly and it brings the explosive expanding. It is formed through the correlation among them and followers. Another work of pioneers is to determine the capacity of system. The maximum number of adopters in the society depends on the number of pioneers. Generally speaking, global influence amplifies the function of pioneers. It reduces the necessary pioneers’ number to expand, helps to form the critical mass and increases the capacity. It also prompts to spread to followers from pioneers.

Our simulation integrates two levels having discussed separately: indivisibles and a society consists of them. We confirm the correlation among individuals brings about fashion, and the society influences them to emerge fashion. It supports the observations of instability and dynamics insisted in sociology.

As a future study, it is required the analysis of introducing other features of dynamic society such as agents’ movements. Another plan is to develop society round by round for verifying the rigidity of system.

REFERENCE