Virtual Geographic Environment based Intelligent Simulation of SARS Diffusion

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Abstract: This paper presents an intelligent SARS diffusion simulation method using Agent technology in Virtual Geographic Environment (VGE) based on current results of SARS research. VGE is the 3D carrier space of SARS diffusion, and Agent technology is used to describe the diffusion process. Meanwhile, a SARS diffusion model is designed and an intelligent simulation method is proposed. Preliminary results show that combination of VGE and Agent technology can simulate and clarify the diffusion process and evolutionary mode of SARS vividly from a time and space perspective.

Key words: Virtual Geographic Environment; Agent; SARS diffusion; intelligent Simulation

1. Introduction

SARS (Severe Acute Respiratory Syndrome), which is also called non-typical nature pneumonia, is a kind of new serious respiratory epidemic. Since its breakout in 2003, it has erupted one after another in China Mainland, Hong Kong, Taiwan and other regions. It is not only a serious threaten to people's health, but also is a great menace to social stability as well as the economical development. The urgent situation has drawn many researchers' attention and it has become a hot research topic recently. With statistical analysis, mathematic modeling, model analysis and so on, they research into SARS diffusion space-time characteristic rule, future development, the effect of epidemic situation control measure etc.

However, so far, all research findings about SARS are simulated and explained by traditional two-dimensional chart or mathematic formula. Though it can show the diffusion tendency and evolution situation of SARS, it can only give an abstract depict from the aspect of time. It is difficult to establish the explicit evolutionary process from the aspect of space. Based on this point, the author designs a SARS diffusion model and a intelligent simulation method, instead of using traditional two-dimensional chart, it can simulate and predict SARS characteristic, the trend, the diffusion and the proliferation and help the public understand the diffusion process about SARS and the way SARS evolves more clearly and directly.

2. Agent technology based virtual Geographic Environment

2.1 Virtual Geographic Environment

Virtual Geographic Environment (VGE) is derived from distributed GIS. VGE has been integrated with computer network technology, virtual reality technology, multi-media technology and so on. It can not only express geographic information in a visualized way and acquire space information, but also meet the practical need of communication between people based on geographic information.

On the narrow sense VGE is a network based multi-user virtual 3D environment. It can be used to deploy multi-dimensional geological data, simulate and analyze complicated geographic phenomena process, support visual and non-visual geological data, future scene prediction, design and planning, cooperative work, colonial strategy. It can also be used in geography education, touristism and entertainment.

VGE is the combination of many important technologies, such as virtual reality technology, network technology, computer simulation, and database and Agent technology. Agent technology, also called intelligence subject, originated from distributed Artificial Intelligence. In the beginning, Agent technology is proposed as a computation model in Artificial Intelligence.

Agent technology distinguishes itself from other traditional technology in its main characteristic. It is self-controlled, target driven, intelligent. It can adapt to surroundings and affect environment through sociality and study. It can also pursue target independently. Agent technology is a breakthrough of
traditional technology. It is strong open, flexible and adaptable.

2.2 Application of Agent technology in VGE

As a newly emerged subject, VGE theory comprises a lot of new technology including Agent technology. Despite the fact that combination of Agent technology and VGE is under discussion and study, we can find it is essential to apply Agent technology to VGE.

Agent technology has properties such as cooperation, intelligence and independence which can be used to search for distributed magnanimity data, filter information when dealing with distributed data and parallel computation, strengthen computational capability, help deal with magnanimity data in VGE and improve system efficiency. Its communicative ability, study and reasoning ability make some functions such as self-evolution of virtual environment, object's independent activity possible.

So Agent technology is an important method that can be used to solve problems in communications between human and environment or among people. It not only solve the problem of how to obtain data, cooperate distributedly in virtual environment, but also show the characteristic of regarding people as the centre from the expression way and individualized respect in VGE. Agent enhances its ability of dealing with complicated problem of VGE constantly by communicating with other Agent. Besides, individual Agent with field knowledge for example, human-machine interface Agent can adjust its own response manner by studying communication between user and VGE to enable the user to concentrate on dealing with the present task in the multi-task complicated environment thus efficiency can be improved.

From above introduction, we can find that Agent technology is one of the most important technologies of VGE. It is predicted that Agent technology will play a extremely important role in VGE.

3. Design of VGE based Intelligent Simulation of SARS Diffusion

3.1 Intelligent Simulation of SARS Diffusion

It is a new attempt of epidemic research to simulate SARS diffusion using Agent. First of all, Agent’s independency can well represent people’s irregular independent behavior and activity in real world. Its behavior is similar to that of human. Second, Agent’s behaviors and state change at any moment reflect SARS diffusion process and result. If we regard the whole diffusion process as a curve, intelligent simulation can clearly show particular state of every point on the curve. So simulating SARS diffusion with Agent is undoubtedly a comparative idea.

Combining SARS diffusion model, this paper designed Agent individual inner structure. It also designed its intelligent simulation behavior process in detail.

![Agent inner structure chart](image1)

As picture 1 show, public base is the knowledge base that all Agents share. SARS Model offers
dynamics support and basic rule for it, and instructs Agent’s Strategy at the same time. Agent parses
outer message by Parse, then put the parsed message into Knowledge base. Knowledge base includes
other types of information such as rule, etc. Strategy engine guide the behavior of Agent by querying
information stored in Knowledge base. After each step, the system writes in key information to
Directory Server after state is changed. The information is used for other Agent or system query. Objects
which are closely related to SARS model are Knowledge base and Strategy engine.

1、Knowledge base
Rules are the foundation of Knowledge base. It guides the behavior of Agent. Shared Public base is
the tightest connected parts between system and SARS diffusion model. It clearly defines the rules
Agent should follow in SARS diffusion. It also instructs evolution of the whole Agent system.

As table 1 shows, according to model design, we divide Agent into four kinds: Healthy (the healthy
one), Infected (the patient in latent period), Patient (the patient) and Healer (the medical staff), we
choose these attributes as their second attribute (The first attribute is ID number.). We divided VGE into
following three types of areas according to its function and distribution: Free Area (the normal activity
area), Insulate Area (the isolated area), and Hospital (the hospital).

Different kinds of Agent have different rules. So for different Agents we can divide shared Public
base into four kinds as shared knowledge base of each kind of Agent. Table 1 illustrates state transform
of Agent.

Table 1 state transform chart(for Condition ②②②②、③③③③, refer to table 4-2)

<table>
<thead>
<tr>
<th>Precondition</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>isInfected</td>
</tr>
<tr>
<td>Healthy</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Infected</td>
<td>Yes</td>
</tr>
<tr>
<td>Patient</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Healer</td>
<td>No</td>
</tr>
</tbody>
</table>

Table 2 instruction of condition

<table>
<thead>
<tr>
<th>Precondition</th>
<th>Description</th>
<th>Representation</th>
</tr>
</thead>
<tbody>
<tr>
<td>②</td>
<td>Delayed</td>
<td>Infected person didn’t go to hospital immediately after latent period, infected probability (P) goes up with the increment of days (T)</td>
</tr>
<tr>
<td>③</td>
<td>In Patient, according death rate D, compute the number of death and allocate it to Patient random</td>
<td></td>
</tr>
</tbody>
</table>

In the initialization stage, the public rule base is empty, when the system begins to run, with each
step of Agent historic state and change are added into the rule base in order for future query and call.

2、Strategy engine
Strategy engine is Agent’s response to outside. It encapsulates Agent’s intelligence and takes charge
of Agent’s behavior (Action). It is consisted of a serial of Strategy. The first function of strategy engine
is to judge whether current Agent satisfied target in knowledge base (Target). Its second function is to
ensure that reactive content in knowledge base mirrors the true world as close as possible. Action of
Agent should change the external world and one’s own state directly according to the information in the
knowledge base or write new information into the knowledge base for upgrading so that it can reflect the real world more truly.

In each step of strategy, the strategy engine first confirms whether the plan is successfully executed. If there is no plan in existence, it makes one for the target with highest priority. If the plan can’t be produced, it makes plan for the target with highest priority. This process repeats until a new plan is made or all achieved targets have been attained.

The object-oriented action process of Agent is made up of a series of State and behavior Strategy. The state transition process can be described as follows:

<table>
<thead>
<tr>
<th>Precondition</th>
<th>Actions</th>
<th>State2</th>
</tr>
</thead>
<tbody>
<tr>
<td>State1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Actions represents a series of development. It is an essential way from State1 to State2. Precondition includes trigger condition and quit condition that one State changes to another. One State can be triggered to another State by external or internal incidents and enter another state. When quit condition is satisfied, Agent terminates and drops out of this state and is prepared to enter the next state.

Strategy can be separated particularly as group strategy and individual strategy. Group strategy is macro-strategy based on the whole Agent system. It presents as specific result of SARS evolution in the system, including intermediate result such as the number of new infected cases, death cases and cured cases after the end of a period. As for Agent individual, individual strategy includes which state it will enter, whether it should be insulated, whether it should go to hospital for treatment and so on. The strategy of different Agent has nothing in common with each other. But drawing a conclusion is the result of combining whole strategy with individual strategy.

Take confirming the number of the infected cases for example. We should know how many people are infected as well as who are infected and the state after being infected. The preceding part of this task is implemented by whole strategy. First, the infected probability P is known when the healthy contact with patient in contagious period. According to the number of people keep in infective touch with the infected and the infected probability, we draw the total number of the infected. Then we assign the infected cases randomly among these people.

The specific method is to create several unary array in Strategy engine. We put the ID of all people who keep in infective touch with different patients in a period into different unary array. (People who contact with the same patient are in the same array.) The infection rate of different arrays might not be the same. Before a period finished, according to the size of the array and infection rate, we draw the number of the infected in each array. Finally, the system carried on random allocation to members of each array. To reduce the complexity of model implementation, we can assign properties in-control or out-of-control to infected members and healthy members of each array separately. Later the infected Agent determines state (e.g. whether be insulated or be sent to hospital) or specific action according to its own Public base by its own Strategy engine.

4. Summary

This paper combined VGE and Agent technology. The author designs a SARS diffusion model and a intelligent simulation method, instead of using traditional two-dimensional chart, Simulating SARS diffusion intelligently from the three-dimensional space distribution well utilize independent initiative of Agent. It made the evolution of the model closer to real world. This paper designed SARS diffusion model as well as knowledge base and strategy engine which associate with SARS model closely. It also implemented instruct action of Agent through a series of rules.

The author believes that by combining VGE and Agent technology, simulation of SARS diffusion can help the government and the public know diffusion and evolution of infectious disease which is similar to SARS, counter measures like “early discover, early report, early insulate, early cure” as well as other means of control of epidemic situation more directly. It is helpful to increase the public’s knowledge about infectious disease e.g. SARS. It can also enhance prevention and cure and control of infectious disease. Meanwhile it can offer scientific basis for strategy of concerned departments such as the government etc so that they can take more effective measure and provide test method.
Acknowledgements

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References


[7] George Anastassakis, Themis Panayiotopoulos, and Tim Ritchings. Virtual Agent Societies with the mVITAL Intelligent Agent System