Using Qualitative Technology for Modeling the Process of Virus Infection*

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Abstract. The quantitative analysis of viral infection dynamical model can’t be processed easily due to the lack of complex quantitative knowledge in such biological system; therefore, the methods based on qualitative analysis become an alternative solution to researches in the complicated biological process. In this paper the qualitative technology is introduced to model and analyze the process of virus entry. A rough model is proposed first to be the foundation of further research. With more knowledge in the process, the framework is expanded by inserting the qualitative description of different kinds of factors that have interactive influence on the process of virus entry. The factors are described qualitatively in influencing degree, and the qualitative model is built based on the interaction among these influencing factors and the viruses and cells. The judging matrices are constructed according to the qualitative model and the coherence of these matrices is verified. A qualitative analysis about the process is given finally.

1 Introduction

In the field of virus infection, the researching methods can be roughly divided into three categories: the theoretical study, the experimental study and the emulational study. Generally speaking, in the traditional researching processes, complete quantitative knowledge is mostly needed to be the prerequisite to more advanced studies. Unfortunately, quantitative information necessary to evaluate and analyze the process of viral entry is usually hard to gain. Thus, with only incomplete quantitative knowledge the traditional qualitative methods to model the process are less effective.

For example, a number of studies on influenza virus have shown that virus particles enter the cell by endocytosis[1-2]. Moreover, amantadine, an inhibitor of influenza virus infection[9], has been shown to act at an intracellular location[10]. Other studies suggest that influenza virus, like Sendai virus, may fuse directly with the plasma

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membrane of the cell[11]. The process of viral entry can’t be fully quantitatively described even now[5-6]. One reason is that the entry mechanisms used by many of them remain unclear. Another important reason is that lots of quantitative knowledge in the process can’t be gained easily. In the process of viral entry, there are lots of factors that have influence on viruses and cells[7-8], e.g. the percentage of virus binding to cells increases when temperature gets higher[12]. Karl s.Matlin[13] found that when PH>5, the percentage of virus binding to cells decreases if PH decreases. The existence of positive ion in the environment may also affect the process of viral binding and entry.

However, as discussed above, the influence in the environment is difficult or impossible to express and analyze fully quantitatively. What we know is often the qualitative interaction among the variables and factors. So the qualitative technology comes to become our alternative solution to researches in the complicated biological process. Researchers have also shown much interest in such complex systems with incompletely known knowledge. In reference [3] the authors use a qualitative method to describe the interaction among the factors existing in viral infection system and build qualitative viral infection model. If the system is given as ordinary differential equation, B.Kuipers writes its qualitative model in the formula of qualitative differential equation (QDE) and reasons the process qualitatively[14].

To address the problem, in this paper we introduce a qualitative modeling frame to promote the research in the field. The basic idea is to model the process of virus entry, taking the influencing factors into account qualitatively.

We propose a rough framework to be the foundation of further research. With more knowledge in the process, the framework is expanded by inserting the qualitative description of different kinds of factors that have interactive influence on the process of virus entry. The factors are described qualitatively in the influencing degree, and the qualitative model is built based on the interaction among these influencing factors and the viruses and cells. The judging matrices are constructed according to the qualitative model and the coherence of these matrices is verified finally. Based on the technology connecting qualitative to quantitative technology, we joint the behavior of viruses and the environment and the cells together.

2 The Preliminary Knowledge

To qualitatively model the interaction between viruses and cells and the influence factors in the environment, the first difficult is to qualitatively specify the involved factors among the system, and the specification of interaction terms should be in favor of the reasoning of qualitative simulation. We propose the model that can describe the initial framework of the process, as shown in Fig.1.