Chapter 14

Using Probability Distributions in Parameters of Variables at Agent–Based Simulations: A Case Study for the TB Bacillus Growth Curve

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ABSTRACT

Even treatable and preventable with medication, tuberculosis (TB) continues to infect and cause deaths globally, especially in the poorest countries and in most vulnerable parts of the rich countries. Given this situation, the study of the growth curve of Mycobacterium tuberculosis, which causes tuberculosis, can be a strong ally against TB. This study models the growth curve of Mycobacterium tuberculosis using simulation based agents, aiming to simulate the curve with the minimum possible error when compared to in vitro results. To implement this model, the agents represent the bacteria in their habitat and how they interact with each other and the environment. Some parameters of the agents are modelled with probability distributions.

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INTRODUCTION

Tuberculosis (TB) is a major public health problem, affecting predominantly low and middle-income countries, developing among immigrants, poorest and vulnerable parts of high-income countries (Lönroth et al., 2015). According to Burgos and Pym (2002) *Mycobacterium tuberculosis*, which causes tuberculosis, is one of the most successful bacterial pathogens in the humanity history.

A report published in 2015 by the World Health Organization (WHO) estimates that in the year 2014 were 9.6 million new cases of tuberculosis (TB) and 1.5 million deaths, and together HIV virus, tuberculosis presents one of the biggest causes of deaths from infectious diseases.

Therefore, the study of *Mycobacterium tuberculosis* growth curve becomes extremely important, because this study will test behavior hypotheses in cases of environmental stress (Voskuil et al., 2004), verify bacillus drug reactions and help to develop new ones (Andries, 2005). For these objectives, growth curve are important not only to determine its dynamic but also sampling bacteria in different phase of growth to determine its behavior variation during the growth. However, the tuberculosis bacillus has a very slow rate of population growth, form clumps to grow and requires enrichment medium. Because this behavior, in vitro experiments are very costly and need the maximum of tools in order to rational design of the studies involving the growth curve and sampling of the bacteria. According to Rebonatto (2000), computer simulations methods have been shown to be effective in situations involving high costs and risks. Computer simulations allow the study of various problems more effectively, as possible, in most cases, the viewing behavior, and specific details of the study object.

Multi-agent systems, a field of artificial intelligence, enables, by means of their tools, to simulate behavioral rules of a system computationally. According to Garcia and Sichman (2005), “Agents are computer characters that act according to the program set, directly or indirectly, by a user. They can act alone or in communities, trainees multi-agent systems “.

Many measurable phenomena present in nature have probability distributions similar to some probabilistic models. Often, these models are used to represent the probability density function of random variables. Probabilistic models are useful in many real situations, to make the variable predictions study and assist in decision support. It is believed that the main variables that model the Mycobacterium tuberculosis bacillus growth curve also resemble a probabilistic model.

The main goal of this work is to model the tuberculosis growth curve, using agent-based simulations, where the values of some variables are drawn from probability distributions, thus making the system developed more similar to real systems.

TUBERCULOSIS

Tuberculosis (TB) is a contagious infectious disease transmitted by *Mycobacterium tuberculosis*. It was discovered on March 24, 1882 by the German scientist Robert Koch, and so the tuberculosis bacillus, *Mycobacterium tuberculosis*, is also known as Koch’s bacillus.

*Mycobacterium tuberculosis* is an intracellular pathogen that can affect various animal species, although humans are the main hosts. It grows with more success in tissues that contain high levels of oxygen, such as the lungs (Lawn & Zumla, 2011).