Simulating avascular tumours with Membrane Systems

M.A. Gutiérrez-Naranjo; M.J. Pérez-Jiménez; F.J. Romero-Campero

Research Group on Natural Computing
Department of Computer Science and Artificial Intelligence
University of Sevilla
Avda. Reina Mercedes s/n, 41012, Sevilla, Spain
{magutier, marper, fran}@us.es

Abstract. Tumour growth is a fundamental problem which has received considerable attention by the scientific community. In the earliest stages of development tumour growth seems to be regulated by direct diffusion of nutrients and wastes from and to surrounding tissue. In this paper we present an approach of the use of Membrane System techniques to simulate and predict the growth of a tumour in the avascular stage. We present a preliminary version of our software to simulate this growth and some future research lines.

Keywords: Avascular tumour growing, Spheroid model, Membrane Systems, Natural Computing

1 Introduction

Tumour growth is a fundamental problem and has received considerable attention by the scientific community. There are many mathematical models that describe the initial avascular stage of solid tumour growth (see [13, 14, 6, 3, 22, 15, 11]. Avascular tumour growth has been widely studied using mathematical techniques, and the resulting models are becoming increasingly sophisticated.

The avascular stage of tumour growth is characterised by small tumours which gain the nutrients and oxygen they need for survival and growth by diffusion from external blood vessels. Since there are no blood vessels within the tumour to supply the mass needed for such volume expansion, this must also enter through the tumour's periphery.

An individual tumour cell has the potential, over successive divisions, to develop into a cluster of tumour cells. Further grow and proliferation leads to the development of an avascular tumour consisting of approximately 10^6 cells which feed on oxygen and other nutrients present in the local environment.

The rapid growth an resilience of tumours make it difficult to believe that they behave as random, disorganised and diffuse cell masses and suggests instead that they are emerging, opportunistic systems. If this hypothesis holds true, the growing tumour and not only the single cell must be investigated and treated as

a self-organising complex dynamic system. This cannot be done with currently available in vitro/in vivo models or common mathematical approaches. We propose the use of Membranes Systems as a new tool for the simulation and study of avascular tumours.

In membrane systems a local, modular and topological modelling of biological phenomena is easily achieved. So using this bioinspired model of computation we can get a detailed representation of each individual tumour cell, of their adaptive behaviours and processes; as well as the interactions amongs cells and between cells and a heterogenous environment. All this features are not easily achieved when using other models like differential equations or cellular automata.

As we will see, membrane systems own several interesting features which make them suitable for this study. In particular, P systems treat the discrete nature of actual cells realistically. Each cell can be seen as independent computing unit with its own behaviour. In this way, a local modelling of the process can be simulated and then, the evolution of the whole tumour can be studied as the sum of all local performances together the network of interactions among the cells.

Besides membrane systems are a flexible framework where different approaches like discrete, continuous, stochastic, etc (see [7], [18], [8]), can be considered within the same model to represent different bits of the biological phenomenon which is been investigated. This interpretation allows the model to serve as an intuitive complement to the results obtained from a continuum model.

The paper is organised as follows: first the spheroid model of avascular tumour growing is presented in the next section. In section 3 we recall some important features of Membrane Systems. The simulation and preliminary results are presented in section 4. Finally, some conclusions and future research lines are given in the last section.

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