Modeling the chemotactic behavior of *Dictiostelium discoidium* using a voxel-based stochastic approach

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Abstract

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Introduction

Materials and methods

Modeling the movement of a single-celled organism is seemingly an insurmountable task; given the complexity if such behavior, a faithful recreation would be computational cal-da-sac. Instead we have chosen to study this behavior at three different levels:

1. *The chemical level*: at this level we simulate the chemical reaction in pre-defined compartments, "voxels", using the Gillespie's method. The formation of pseudopodia is net result of these reactions.
2. *The mechanical level*: the collective outcome of the the chemical reactions is translated into Newtonian equations in order to transform the chemical level into the movement of a physical entity –i.e., the cell– on a surface.
3. *The behavioral level*: The chemotactic response of a single-celled organism to external stimuli separates the realm of goal-less, unguided, and mindless objects from the realm of living entities that change their behaviors vis-a'-vis their *Umwelt*.

The chemical level

In order to capture the intricacies of a single-celled organism, we divided a cell into ? voxels. A voxel is defined as cube with a given volume in which a set of chemical reactions relevant to actin polymerization. We utilize Gillespie's next reaction method to simulate the occurrence of chemical reactions in each voxel (Table 1).

Table 1. Reactions in each voxel.

	Reaction	k
1	RAS $\longrightarrow$ PTEN	
2		

The main hurdle in utilizing a voxel-based approach to simulate the behavior of a single cell, is the fact the reactions in the Gillespie's algorithm occur randomly, but at the same time the diffusion of products form voxel should affect the neighboring voxels; how can we

The mechanical level

The behavioral level

Code availability

Results

Discussion

Supporting information

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Additional information

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References