A new optimal control algorithm for the Keller-Segel problem

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Chemotaxis can be defined as the movement of an organism or cell in relation to chemical agents. This movement can be towards a higher (attractive) or lower (repulsive) concentration of the chemical substance. At the same time, the presence of living organisms can produce or consume the chemical substance, producing nontrivial dynamics between living organisms and chemical substances. In 1971, Keller and Segel [1] introduced the first realistic attempt to capture the chemotactic response of bacteria towards chemical agents in a bounded spatial domain by using a nonlinear parabolic system for two variables; the cell density and the concentration of the chemical signal that the cell feels attracted to.

During this talk I will introduce a new optimal control algorithm for the Keller-Segel chemo-attraction system, where both boundary and distributed controls are considered and both are associated with introducing/removing the amount of chemical substances in the system. The key idea of our approach is to design the optimal control algorithm after discretizing the state problem system, which is done using an upwind finite volume scheme in space and a semi-implicit finite difference in time, with an upwind approximation for the distributed control term. Then, the discrete optimal control is approximated identifying the gradient of the reduced discrete cost via the discrete adjoint scheme. Finally, to minimize the reduced cost functional, we use a gradient descent type method (Adam's scheme). Moreover, I will present numerical results to illustrate the efficiency of the proposed approach.

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Referencias

[1] E.F. Keller L.A. Segel, Traveling bands of chemotactic bacteria: a theoretical analysis, J. Theoret. Biol. 30 377-380 (1971).