Pattern formation by Reaction-Diffusion systems

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Reaction-diffusion systems arise when constructing mathematical models for physical processes in many areas (e.g. chemistry, biology, ecology, and physics). There is an interesting property of some reaction-diffusion systems. That is solutions of some reaction diffusion systems form various types of spatial patterns (e.g. spots, strips etc.). In this research paper Gray-Scott model:

$$\frac{\partial u}{\partial t} = d_1 \Delta u - uv^2 + \eta(1-u)$$

$$\frac{\partial v}{\partial t} = d_2 \Delta v + uv^2 - (\eta + \varsigma)v\,,$$

And FitzHugh-Nagumo model:

$$\frac{\partial u}{\partial t} = d_1 \Delta u + (a-u)(u-1) - v$$

$$\frac{\partial v}{\partial t} = d_2 \Delta v + e(bu - v)\,,$$

are considered. In above models d_1, d_2, η, ς, a, e and b are real valued parameters. Turing's stability conditions for pattern formation are discussed. The main focus of this paper is simulating above systems using finite difference techniques. Implicit finite difference schemes are used in numerical simulations. No-flux boundary conditions are used and parameters and initial states are chosen such a way that Turing's instability conditions are satisfied. In these numerical simulations, interesting spatial patterns are observed for various parameter values and various types of initial states.

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