Turing-Like Reaction-Diffusion Patterns Emerging on Two-Layered Resistive Sheets with Nonlinear Devices

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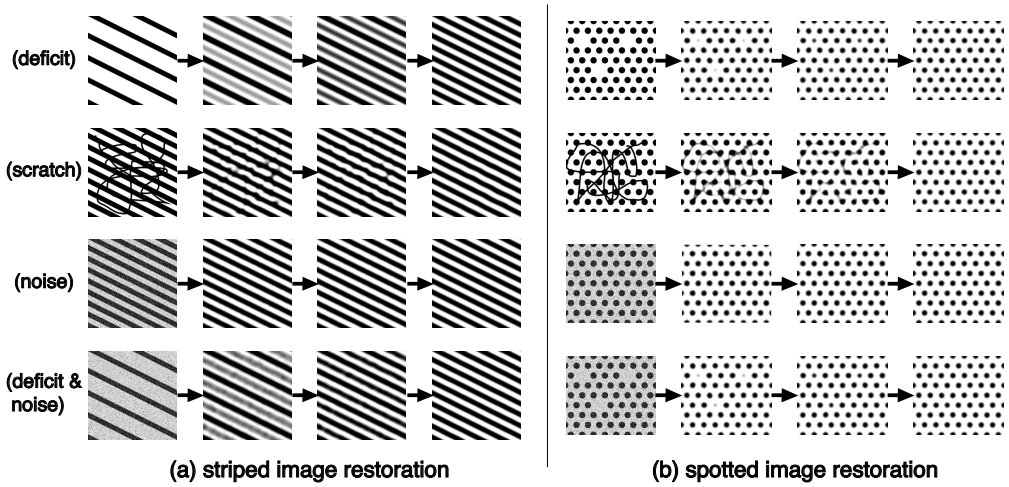
Reaction-diffusion (RD) computers have an unique ability to efficiently solve combinatorial problems with natural parallelism [1]. Among various RD systems, Turing-like (e.g., 2-D striped or spotted) patterns emerging on animal skins, etc., have mainly been shown in 'software' simulations of RD chemicals or physical wetware. In this work, we present a simple mathematical model for a possible 'hardware' RD system that produces Turing-like patterns, for image-processing applications.

Based on Young's digital RD model [2] that generates Turing-like patterns, the authors proposed analog-digital hybrid cellular automata for hardware RD systems (RD chips) [3]. In the model, linear diffusion systems of activators and inhibitors were employed, and they were electrically emulated by discrete capacitor networks in the hawdrare, which prevented us to design high-resolution RD silicon processors.

In this work, we propose an improved model of [3] for completely-different but smart RD hardware architectures. In the new model, diffusion is emulated 'on' a continuous resistive sheet, which can be modeled by a ladder network of discrete resistors. Two-layered 2-D resistive sheets are employed for emulating chemical diffusions of activators and inhibitors, whereas nonlinear feedback devices (conventional amplifiers) are used for emulating interactions between the chemicals. Through theoretical analysis of the proposed model, we found i) the model generated non-uniform and periodic spatial patterns as the equilibrium and ii) spatial frequencies of the generated patterns are inversely proportional to the square root of inhibitor's diffusion coefficients.



The figure above shows numerical simulation results of the proposed model demonstrating image restoration of (a) striped and (b) spotted images. The image restoring ability of the proposed model was qualitatively the same as the previous model in [3], which indicated that the image restoring based on RD computing could be performed on smart hardware; i.e., simple amplifiers and 2-D resistive sheets of polysilicon layers.

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