Nature-Inspired Reaction-Diffusion Algorithm for Image Processing and Computer Vision Applications

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Abstract

We present reaction-diffusion algorithms for image processing and computer vision applications. All of the algorithms utilize the FitzHugh-Nagumo (FHN) type reaction-diffusion models. In the edge detection algorithm, we couple the FHN model with a simple diffusion equation, which computes a local threshold level. In the segmentation and stereo vision algorithms, we couple multi-sets of FAN models with each others; each model governs a segment or stereo disparity.

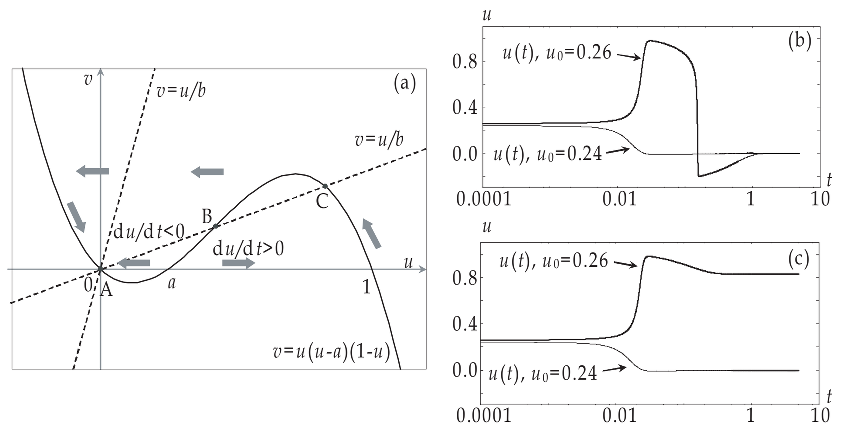
Adamatzky, A., Costello, B. D. L., Masai, T.: *Reaction-diffusion Computers*, Elsevier (2005)

Reaction-diffusion model

FitzHugh–Nagumo Model

FitzHugh, R.: *Biophys. J.* **1** (1961) 445-466
Nagumo, J., Arimoto, S., Yoshizawa, S.: *Proc. IRE* **50** (1962) 2061-2070

$$\begin{cases} \dfrac{\partial u}{\partial t} = D_u \nabla^2 u + \dfrac{1}{\varepsilon}\left[u(u-a)(1-u)-v\right] \\ \dfrac{\partial v}{\partial t} = D_v \nabla^2 v + u - bv \end{cases}$$



One-dimensional Numerical Experiments on Discretized Version of the FitzHugh-Nagumo Model

Nomura, A., et al.: *J. Phys. Soc. Jpn.* **72** (2003) pp.2385-2395
Ebihara et al.: *J. Inst. Image Elect. Engin. Jpn.* **32** (2003) pp.378-385

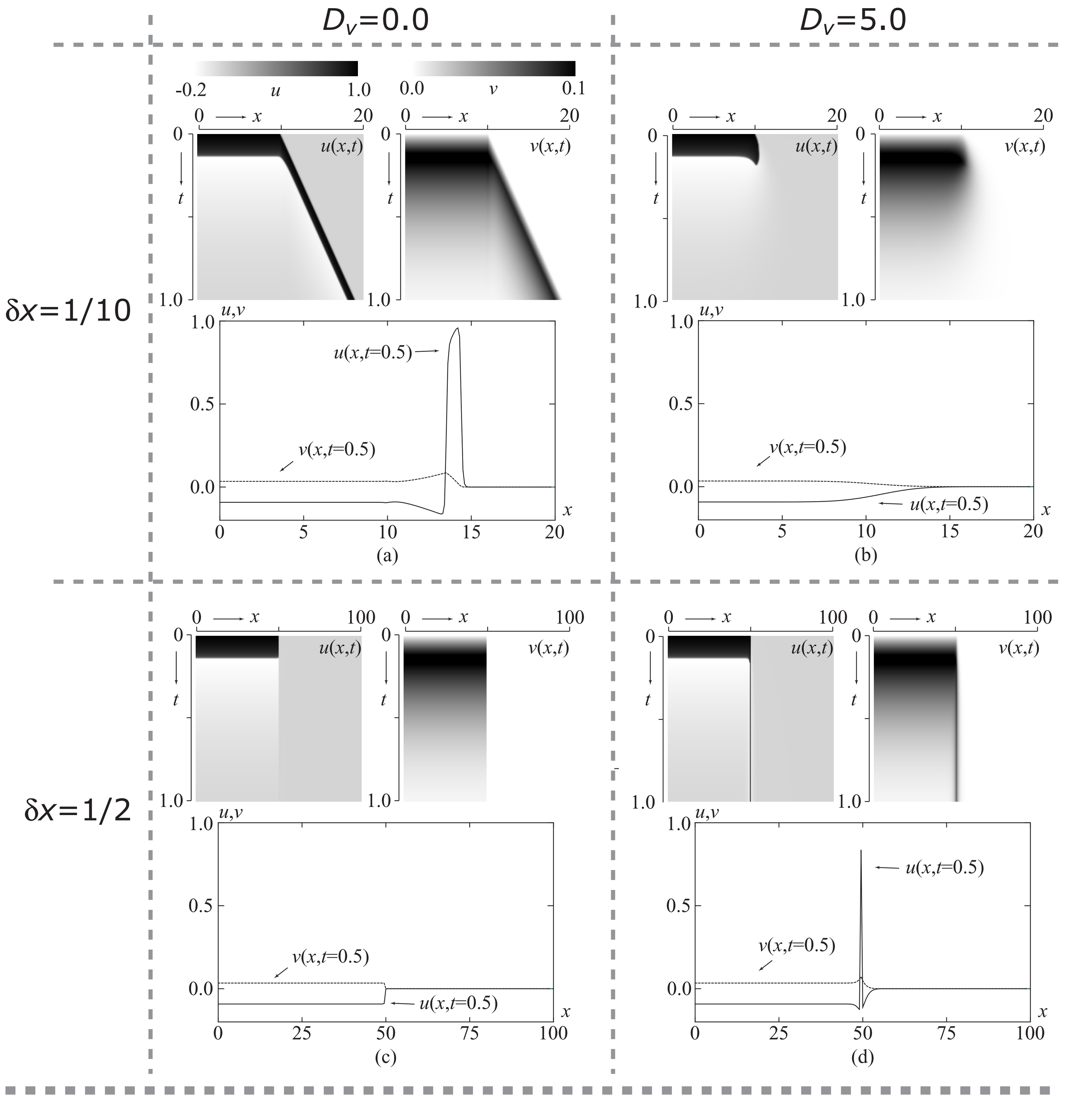


Image Processing & Computer Vision Applications

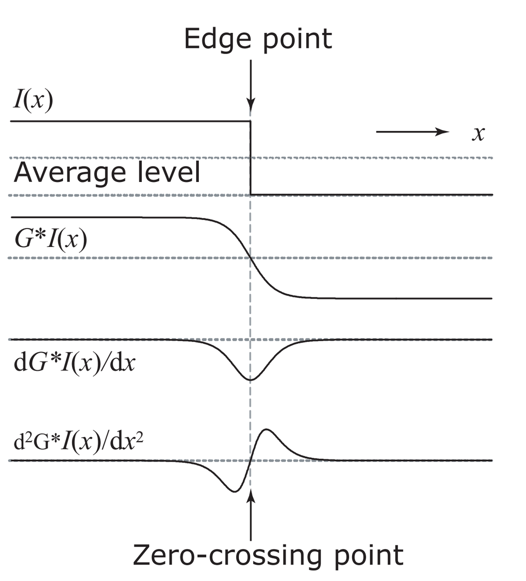
Edge Detection

Nomura, A., Ichikawa, R. H. Sianipar, M., Miike, H.: *Proc. 7th OGRWorkshop* (2007) No.042

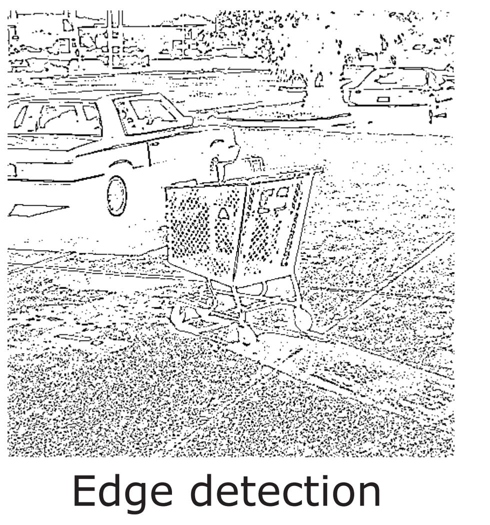
$$\begin{cases} \dfrac{\partial u}{\partial t} = D_u \nabla^2 u + \dfrac{1}{\varepsilon}\left[u(u-a)(1-u)-v\right] \\ \dfrac{\partial v}{\partial t} = D_v \nabla^2 v + u - bv \\ \dfrac{\partial a}{\partial t} = D_a \nabla^2 a \end{cases}$$

Initial conditions

$$\begin{cases} u(x,y,t=0) = a_0 I(x,y) \\ v(x,y,t=0) = 0 \\ a(x,y,t=0) = a_0 I(x,y) \end{cases}$$



Original image
http://marathon.csee.usf.edu/edge



Edge detection

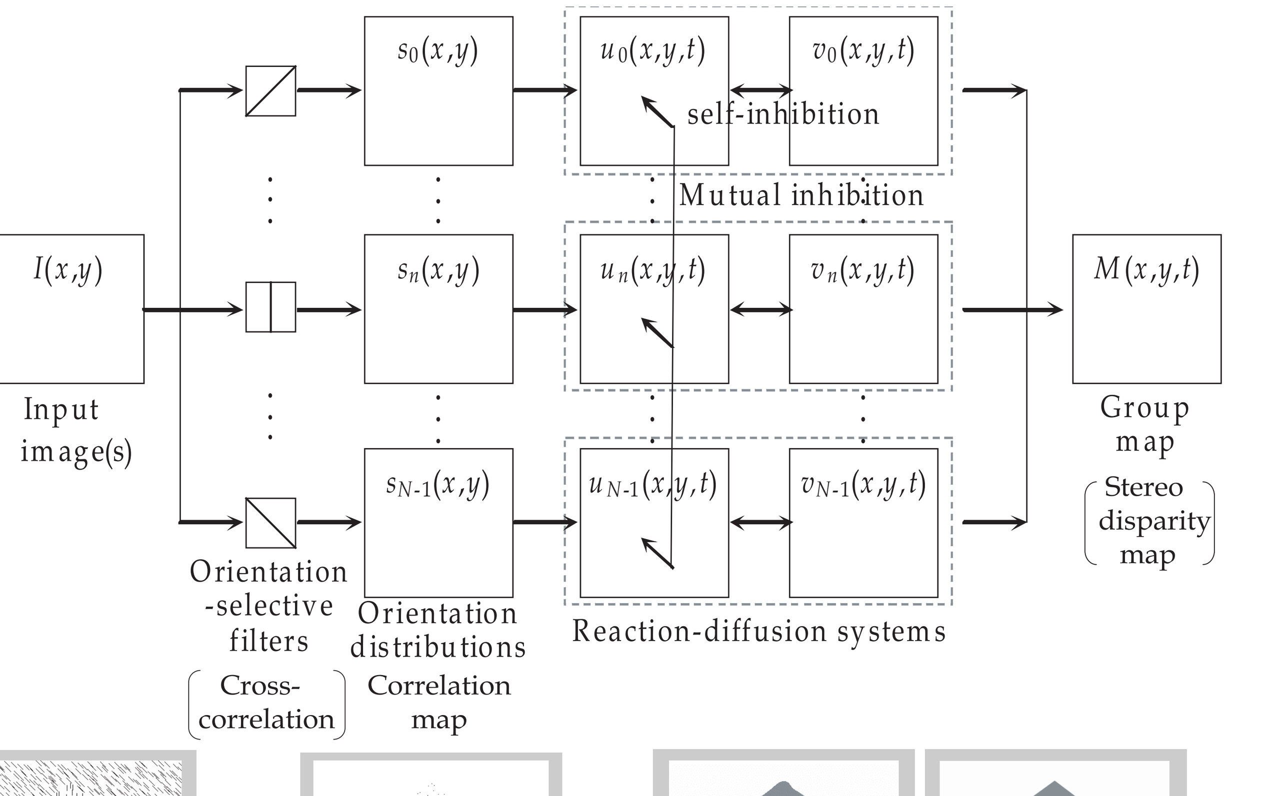
Segmentation & Stereo Vision

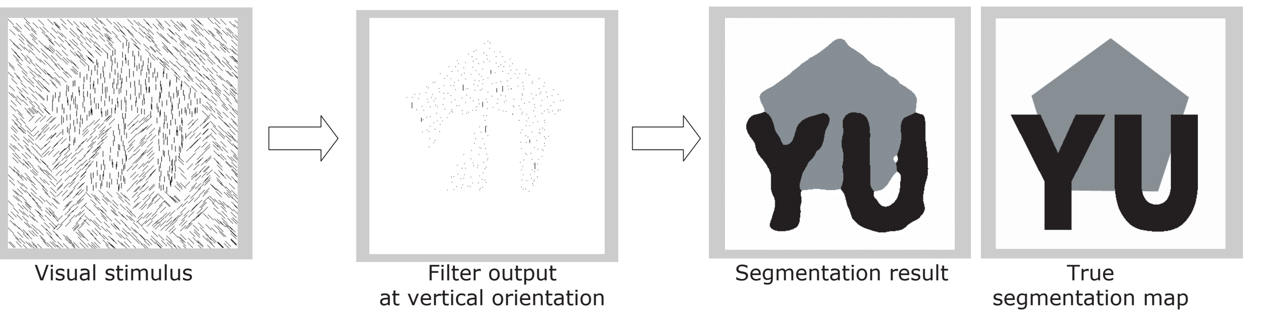
Nomura, A., Ichikawa, M., Miike, H.: *IPSJ Trans. Comp. Vis. & Image Media* **45** (2004) pp.26-39
Nomura, A., Ichikawa, M., Miike, H.: *Machine Vision and Applications* (in press)

$$\begin{cases} \dfrac{\partial u_n}{\partial t} = D_u \nabla^2 u_n + \dfrac{1}{\varepsilon}\left[u_n(u_n - a(U_n))(1-u_n) - v_n\right] + \mu s_n \\ \dfrac{\partial v_n}{\partial t} = D_v \nabla^2 v_n + u_n - bv_n \\ a(U_n) = a_0 + U, \\ U_n = \max\limits_{n' \in \{0,1,\cdots,n-1,n+1,\cdots,N-1\}} u_{n'}(x,y,t) \end{cases}$$

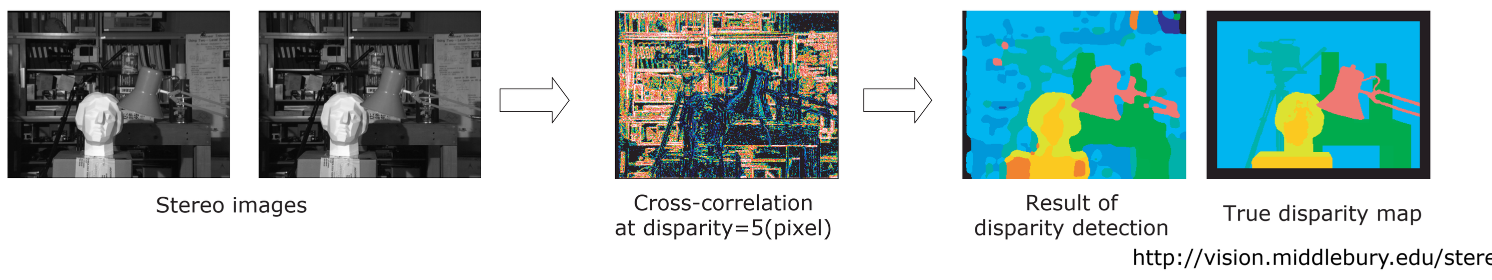
Initial conditions

$$\begin{cases} u(x,y,t=0) = s_n(x,y) \\ v(x,y,t=0) = 0 \end{cases}$$





Visual stimulus | Filter output at vertical orientation | Segmentation result | True segmentation map



Stereo images | Cross-correlation at disparity=5(pixel) | Result of disparity detection | True disparity map

http://vision.middlebury.edu/stereo/

Nomura et al.: "Chapter 4: Reaction-diffusion algorithm for vision systems", in *Vision Systems: Segmentation & Pattern Recognition*, pp. 61-80
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