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An Image Analyzing Method for the Vaguely Grain Boundary Detection by a Reaction Diffusion System

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Abstract

To analyze the images of structures, we often detect the edges of grains. Since the grain boundaries are not so clear, it takes a lot of time to detect them, manually. Here, we present a support method to detect the edge from structure images. We make blurry images clear by solving non-linear partial differential equations numerically. Combining ordinary image analysis methods, we can detect edges of grains easily. In this note, we introduce the results of our method and discuss the possibility of this method.

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Keywords: Reaction diffusion, Edge detection, Homology.

1. Introduction

To detect the edges of grains in structure images, many methods have been developed. Mainly, filtering methods have been studied. For example: Gradient, Roberts, Sobel and so on. If there are variations in brightness in the image, they do not work effectively.

Here, we introduce the edge detection method by solving the reaction-diffusion equation. This method has been developed for the edge detection and the figure-ground separation [1].

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It can achieve a high quality processing of noisy images as compared with the Median filter [2]. Nomura et al. [3] extended this algorithm in order to detect edges in a gray-scale image. Several researchers have observed that a reaction diffusion mechanism works as an image processing system. Kuhnert [4, 5] found that a reaction diffusion mechanism built into a real chemical reaction system worked for visual functions such as the edge enhancement [6, 7].

2. The model equation

The two-variable reaction diffusion system is used as a base of the presented method that is called the FitzHugh-Nagumo (FHN) equations. The FHN equations are a model of nerve membrane [8, 9]. This model with two variables *u(t, x)* and *v(t, x)* is expressed by:

$$\frac{\sigma u}{\sigma t} = D_e \Delta u + \frac{1}{\varepsilon} f(u,v) \quad (1)$$

$$\frac{\sigma v}{\sigma t} = D_i \Delta v + g(u,v) \quad (2)$$

where D_e and D_i are diffusion coefficients for the variables u and v, the parameter ε is a positive small constant ($0< \varepsilon <<1$) and $f(u, v)$ and $g(u, v)$ are reaction terms. The two variables u and v are excitatory and inhibitory variables, respectively. The reaction terms of the FHN model are expressed by:

$$f(u,v) = u(1-u)(u\text{-}a)\text{-}v \quad (3)$$

$$g(u,v) = u\text{-}bv \quad (4)$$

where the parameters a and b are positive constants.

We used the following condition for figure-ground separation: $b>4/(1-a)^2$. The parameter a is the threshold value of u. The value of u goes to the fixed point 0 if the initial value of u is under the threshold value and it goes to another stable fixed point $\left\{b(a+1)+\sqrt{b^2(a\text{-}1)^2\text{-}4b}\right\}/2b$ if the initial value exceeds the threshold value. By utilizing this property, the ambiguous parts of the image are emphasized.

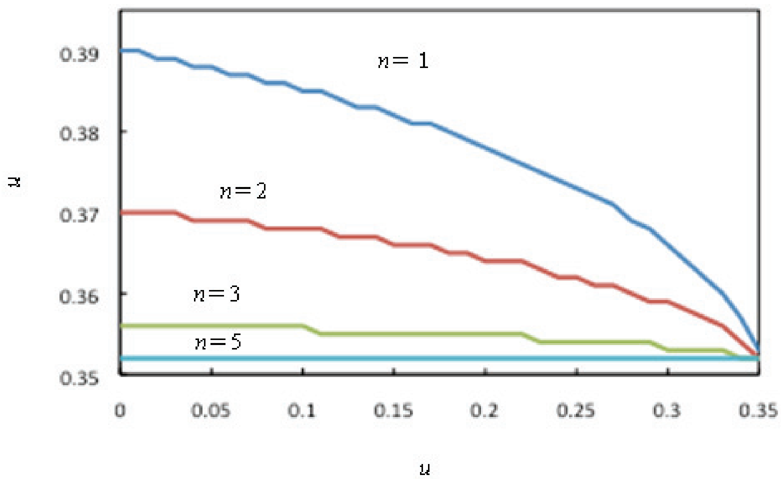

Fig.1. The transverse axis is the initial value of *u* at the ground. The vertical axis is the *u* value of the figure. The value *n* means the pixel number of the figure width. Curves determine the threshold value for the figure-ground separation.